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Post-Pandemic Environmental Awareness in Higher Education: Investigating Its Impact on Students' Knowledge and Attitudes Across Demographics

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ABSTRACT

The development of students' environmental knowledge and attitudes is crucial because it significantly influences learning. However, few studies have examined these foundational aspects, particularly in the post-COVID-19 context. This study examines environmental awareness through the dimensions of environmental knowledge and pro-environmental attitudes, analyzing variations based on gender, duration of study, and academic discipline. Data were collected from university students using a survey method. The sampling technique employed was purposive sampling, involving 547 students enrolled in the Environmental Education course at the University of Riau in Pekanbaru, Indonesia. The findings indicate that students' environmental knowledge is classified as "high," whereas their environmental attitudes are "moderate." A positive correlation was found between environmental knowledge and attitudes, explaining 6.6% of the variance in attitudes. Gender-based differences were significant, but study duration and academic discipline did not show significant effects. These findings highlight the importance of fostering environmental knowledge and attitudes in the post-pandemic context, emphasizing the role of higher education in promoting pro-environmental behaviors and integrating sustainability into the learning process.

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1. INTRODUCTION

Environmental awareness has become increasingly important following the COVID-19 pandemic. The pandemic altered mobility, consumption, social interaction, and environmental engagement (Chin et al., 2020; Lupia et al., 2020). Handwashing, mask use, prolonged indoor activity, and reduced outdoor mobility became common (Fiske et al., 2024). Restrictions on transportation and industrial activity temporarily improved air quality in many countries (Chin et al., 2020; Shi et al., 2020; Xie et al., 2020). However, these improvements varied across geographical and socioeconomic contexts and did not necessarily represent permanent change.

The pandemic also created environmental pressures. Increased use of masks, gloves, food packaging, and other disposable products raised volumes of plastic and medical waste (Prata et al., 2020; Şahin, 2020; Tobías et al., 2020). Household electricity consumption increased as education, work, and public activities shifted to domestic settings. Where electricity generation depends on fossil fuels, greater consumption may increase greenhouse gas emissions and intensify climate change (Aliman et al., 2020). Rising temperatures may cause crop failure, water scarcity, coastal flooding, and prolonged drought (Huang, 2024; Nada, 2019). Thus, the pandemic produced a dual effect: temporary pollution reductions and simultaneous increases in waste and household energy use.

These challenges require urgent and innovative post-pandemic responses (Muhammad et al., 2020; Zaharah et al., 2020). Environmental problems are closely related to awareness, values, knowledge, and attitudes (Ramadhan et al., 2019). Environmental health knowledge is also associated with preventive practices and recognition of the relationship between environmental protection and public health (Ahmad et al., 2015; Huang, 2024). Strengthening environmental awareness is therefore important for sustainability and healthier communities (Setyobudi et al., 2018).

In this study, environmental awareness is treated as an overarching construct comprising environmental knowledge and environmental care attitudes. Environmental knowledge refers to students' understanding of environmental conditions, causes of degradation, and possible solutions. Environmental care attitudes refer to concern, responsibility, evaluation, and willingness to support environmental protection. Pro-environmental behaviour is considered a possible outcome but is not directly measured. This distinction matters because knowledge does not automatically translate into attitudes or behaviour. Hungerford and Volk (1990) identify knowledge as a cognitive foundation for responsible environmental action, but motivation, social norms, self-efficacy, experience, and institutional culture may influence the transition from knowledge to attitude.

University students are strategically important because higher education prepares them to participate in social, scientific, and institutional change (Estrada-Vidal et al., 2017; Nasrullah et al., 2018). As agents of change and future professionals, students can influence peers, initiate environmental programs, and apply academic knowledge to community problems (Anwar et al., 2019; Buana, 2020; Rochanah, 2020). Their adaptive capacities are relevant to post-pandemic challenges (Mahaswa et al., 2021). However, their contribution depends on opportunities to connect classroom knowledge with practical experience. Their intellect and creativity should improve social and environmental conditions (Freestone, 2012; Heijden et al., 2015).

Studies frequently report that women show stronger environmental concern and pro-environmental practices than men (Gökmen, 2021; Müderrisoglu & Altanlar, 2011). These differences should not be interpreted as fixed biological characteristics. In Indonesia, gendered socialization, household roles, educational opportunities, cultural expectations,

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and access to environmental activities may shape environmental consciousness differently. Examining gender differences can support inclusive educational strategies without reinforcing stereotypes.

Educational exposure may influence environmental awareness. Students with higher educational attainment often demonstrate greater knowledge and concern regarding health and environmental issues (Mukhlis et al., 2022). University students are expected to combine scientific and technological literacy with environmental responsibility (Riyanto et al., 2012). Nevertheless, formal education does not automatically strengthen environmental attitudes when sustainability is not integrated into curricula, student activities, or campus policies. Students with stronger environmental understanding may identify problems and propose solutions, but social experience and institutional support may determine whether knowledge develops into environmental care (Gusmadi, 2018).

Previous studies have discussed environmental knowledge, attitudes, demographic differences, and student roles, but these elements are often examined separately. Evidence concerning Indonesian students before and after the pandemic remains fragmented, limiting comparison across periods. This study addresses that gap by examining environmental knowledge and environmental care attitudes among University of Riau students. The conceptual model positions environmental knowledge as the predictor and environmental care attitudes as the outcome, while gender, duration of study, and academic discipline serve as grouping variables. Psychological and social factors are recognized as possible mediators or moderators but are not tested.

Accordingly, this study asks: (1) What are the levels of environmental knowledge and environmental care attitudes among University of Riau students? (2) Do these variables differ according to gender, duration of study, and academic discipline? and (3) To what extent does environmental knowledge influence environmental care attitudes? The hypotheses propose that environmental knowledge positively influences environmental care attitudes, that both variables differ by gender, and that differences may occur according to study duration and academic discipline. The findings are expected to support targeted, inclusive, and experience-based environmental education in Indonesian higher education.

2. METHOD

Research Design and Setting

This study employed a quantitative cross-sectional survey design to describe students' environmental knowledge and environmental care attitudes, examine differences across demographic groups, and assess the relationship between environmental knowledge and environmental care attitudes. The survey design enabled the researchers to collect standardized information from a relatively large number of respondents. This approach is consistent with Nasir's description of descriptive research as a method for systematically and accurately describing the characteristics and relationships among investigated phenomena. It also follows Singarimbun and Effendi's conception of survey research, in which a questionnaire is used as the primary instrument for collecting data from a sample of a defined population.

The study was motivated by the environmental changes associated with the COVID-19 pandemic. Reduced outdoor activities temporarily improved air quality, whereas increased plastic waste and household energy consumption generated additional environmental pressures (Chin et al., 2020; Prata et al., 2020). Moreover, environmental knowledge does not always translate directly into pro-environmental attitudes or practices (Ahmad et al.,

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2015). Universities therefore play an important role in strengthening environmental awareness because students can act as agents of change in sustainability initiatives (Estrada-Vidal et al., 2017; Buana, 2020). The study was conducted at the University of Riau, Pekanbaru, Riau Province, Indonesia. Data collection took place from April to June 2024. This research period has been used consistently throughout the revised manuscript to clarify the chronology of the study and confirm that data collection preceded manuscript submission.

Participants and Sampling

The participants were undergraduate students enrolled in the Environmental Education course at the University of Riau. Purposive sampling was used because the study required respondents who had received relevant academic exposure to environmental topics. The inclusion criteria were active enrolment in the course, willingness to participate voluntarily, understanding of the study information, and attendance at a minimum of 80% of course meetings. Students whose attendance was below 80% or who submitted incomplete questionnaires were excluded.

The minimum sample size was calculated as 231 respondents based on a 95% confidence level and a 5% margin of error. A total of 547 eligible responses were included in the analysis, exceeding the minimum requirement. The participants comprised 132 male students (24.1%) and 415 female students (75.9%). Based on study duration, 271 respondents were first-year students and 276 were second-year students. Participants represented ten faculties, as presented in Table 1.

Table 1. *Demographics of Respondents*

Characteristic	Sub- Characteristic	N	Percentage (%)
Gender	Male	132	24.1
	Female	415	75.9
	Total	547	100
College Year	First-year	271	49.5
	Second-year	276	50.4
	Total	547	100
Faculty	Faculty of Teacher Training and Education	70	12.8
	Faculty of Mathematics and Natural Sciences	65	11.9
	Faculty of Engineering	60	11
	Faculty of Economics and Business	58	10.6
	Faculty of Agriculture	55	10.1
	Faculty of Fisheries and Marine Science	50	8.2
	Faculty of Law	45	8.2
	Faculty of Social and Political Sciences	50	9.1
	Faculty of Medicine	47	8.6
	Faculty of Nursing	47	8.6
	Total	547	100

For comparative analysis, the faculties were classified into Science and Humanities categories. The Science category included the Faculties of Mathematics and Natural Sciences, Engineering, Agriculture, Fisheries and Marine Science, Medicine, and Nursing. The Humanities category included the Faculties of Teacher Training and Education, Economics and Business, Law, and Social and Political Sciences. This classification was used to provide adequate group sizes for statistical analysis. However, grouping ten faculties into two broad categories may conceal variations in curricular exposure and environmental learning among individual faculties. The findings should therefore be interpreted as comparisons between

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broad disciplinary categories rather than as evidence that all faculties within each group share identical characteristics.

The unequal gender distribution reflected the composition of students enrolled in the Environmental Education course rather than a predetermined sampling quota. Although the Mann-Whitney U test can accommodate unequal group sizes, the smaller number of male respondents may reduce the precision of gender-based comparisons. Gender differences were therefore interpreted cautiously and were not regarded as inherent differences between male and female students.

The questionnaire was distributed through course-based WhatsApp groups and individual messages. However, the total number of students who received or opened the questionnaire link was not formally recorded. Consequently, a conventional response rate could not be calculated, and potential non-response bias could not be fully assessed. In addition, because all respondents were recruited from one university and one course context, the findings cannot be generalized directly to the entire Indonesian university student's population.

Research Instrument

Data were collected using an online questionnaire administered through Google Forms. The questionnaire link was distributed individually and through student WhatsApp groups. Online distribution facilitated data collection and reduced paper use, which was consistent with the environmental orientation of the study. The first page of the questionnaire provided information about the research objectives, voluntary participation, confidentiality, and completion instructions. Only students who provided informed consent were permitted to continue.

The questionnaire consisted of 24 statements divided into two constructs. Environmental Knowledge consisted of 12 items measured using a five-point agreement scale ranging from Strongly Agree to Strongly Disagree. Environmental Attitude consisted of 12 items measured using a five-point frequency scale ranging from Always to Never. The different response formats were used to reflect the conceptual distinction between perceived understanding and the frequency of attitude-related tendencies. Because the two constructs used different response anchors, their raw scores were calculated and interpreted separately. The scores were not treated as directly equivalent measurements. Environmental knowledge items assessed students' understanding of environmental cleanliness, personal hygiene, environmental education, and environmental protection in the post-pandemic context. Environmental attitude items assessed students' concern, responsibility, sensitivity, and willingness to maintain environmental quality.

Table 2. *Questionnaire of Environmental Knowledge*

Statement Item	Question number	Item Validity
University students are obligated to attend Environmental Education lectures.	1	0.163
University students must understand the importance of maintaining environmental cleanliness post-pandemic**.**	2	0.137
University students must be aware of the importance of handwashing after the pandemic.	3	0.250
The obligation to attend lectures diligently is not required for university students.	7	0.356
The obligation to maintain environmental cleanliness is unnecessary, as pandemic transmission is not directly caused by such factors.	8	0.231

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Students only need to maintain personal hygiene and do not need to wash their hands frequently after the pandemic.	9	0.395
I study diligently in Environmental Education lectures to enhance my environmental knowledge and awareness.	13	0.278
I strive to maintain personal and environmental cleanliness to prevent another pandemic outbreak.	14	0.416
I try to apply the knowledge I have acquired in Environmental Science lectures after the pandemic**.**	15	0.394
I take Environmental Education courses seriously only to fulfil academic obligations and obtain grades.	19	0.510
I am not accustomed to cleaning my surroundings, home, or room, as it is not part of my routine.	20	0.346
I am not accustomed to following regulations or recommendations regarding the importance of maintaining environmental cleanliness post-pandemic**.**	21	0.369

Table 3. *Questionnaire of Environmental Attitude*

Statement Item	Question number	Item Validity
University students should develop the habit of maintaining environmental cleanliness in the post-pandemic period.	4	0.338
University students' environmental awareness should continue to be enhanced, even after the pandemic.	5	0.461
By maintaining environmental cleanliness, I can protect myself from future pandemics and apply the knowledge gained from Environmental Education courses.	6	0.558
The environment does not need to be tidy, clean, or aligned with recommendations, as it is not directly related to pandemic outbreaks.	10	0.725
Not all university students are concerned about environmental cleanliness after the pandemic.	11	0.470
Everyone understands the importance of enhancing self-protection and environmental cleanliness, although many still do not practice it after the pandemic.	12	0.331
I strive to consistently maintain personal and environmental cleanliness in the post-pandemic period.	16	0.507
I am concerned that poor environmental quality may contribute to the resurgence of pandemic-related viruses.	17	0.553
I feel not disturbed by individuals, friends, or family members who are indifferent to environmental cleanliness after the pandemic.	18	0.407
I am indifferent to advisories about maintaining environmental cleanliness in the post-pandemic period.	22	0.413
I do not worry too much about pandemic outbreaks, so I do not see the need for extra efforts in cleaning the environment.	23	0.647
I only realized the importance of maintaining environmental cleanliness after experiencing its negative consequences.	24	0.527

The instrument was developed based on established environmental awareness and environmental education frameworks (Hungerford & Volk, 1990; Martini., 2019; Pusparani et al., 2021; Agustin et al., 2020; Putri et al., 2023). These theoretical references were used to align the questionnaire items with the cognitive and attitudinal dimensions of environmental awareness.

Several questionnaire items were negatively worded to reduce acquiescence bias. Before composite scores were calculated, responses to negatively worded items were reverse-coded so that higher scores consistently represented greater environmental knowledge or stronger environmental care attitudes. The reverse-scoring procedures were applied before

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descriptive and inferential analyses. Composite scores were subsequently classified using the scoring categories presented in Table 4.

The study relied on self-reported responses. Therefore, the results may have been influenced by social desirability, recall error, or respondents' tendency to provide answers perceived as environmentally responsible. The questionnaire measured perceived knowledge and environmental care attitudes rather than directly observed environmental behaviour.

Instrument Validation and Reliability

The instrument underwent readability and expert-content evaluation before the main data collection. The readability assessment examined whether the instructions, wording, and response alternatives could be understood by the target respondents. Expert evaluation assessed the relevance, clarity, adequacy, and alignment of each statement with the constructs and research objectives. These procedures were used to establish initial content validity. Construct validity was examined through item-level correlation analysis using SPSS version 23. Construct validity is required to determine whether an instrument adequately represents the theoretical construct it is intended to measure (Brown, 2000). The item-validity coefficients ranged from 0.137 to 0.725, as shown in Tables 2 and 3.

Several items, particularly Items 1 and 2, produced coefficients of 0.163 and 0.137, respectively. These coefficients were below the commonly used criterion of 0.30 and therefore indicated weak item discrimination. The items were retained because the expert assessment considered their content contextually relevant to environmental education and post-pandemic environmental awareness. Nevertheless, their retention represents a psychometric limitation and may reduce the construct validity of the composite measurement. The results derived from these items should consequently be interpreted cautiously.

A separate pilot study involving an independent sample was not conducted. Future instrument development should revise or remove items with low validity coefficients and conduct pilot testing using an independent group of respondents. Exploratory factor analysis or confirmatory factor analysis should also be applied to examine whether the items adequately represent distinct environmental knowledge and environmental attitude dimensions. Reliability analysis yielded an overall Cronbach's alpha coefficient of 0.79. This value exceeded the minimum internal consistency criterion of 0.70 recommended by Nunnally & Bernstein (1994), indicating acceptable overall reliability. Cronbach's alpha was interpreted as an estimate of internal consistency and was not compared with the item-validity threshold because reliability and item validity represent different psychometric properties.

Table 4. *Scoring Categories for Environmental Awareness*

No	Score	Category
1	73 – 96	Very High
2	49 – 72	High
3	25 – 48	Moderate
4	0 – 24	Low

Data Analysis

Data were analyzed using SPSS version 23. Before statistical testing, the researchers examined response completeness, coding accuracy, reverse-scored items, score distributions, and potential outliers. Descriptive statistics were used to summarize

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respondent characteristics and determine the levels of environmental knowledge and environmental care attitudes. Frequencies and percentages were used for demographic variables, while composite scores were summarized using appropriate measures of central tendency and dispersion.

The normality test produced a significance value of 0.001. Based on an alpha level of 0.05, this result indicated that the data were not normally distributed. The homogeneity test also produced a significance value of 0.001. This result indicated that the assumption of equal variances across the compared groups was not satisfied. It did not indicate that the data were homogeneous. Given the non-normal score distributions, unequal variances, ordinally derived composite scores, and unequal group sizes, the Mann-Whitney U test was used as a non-parametric alternative for group comparisons. The test examined differences in environmental knowledge and environmental care attitudes according to gender, duration of study, and academic discipline. Statistical significance was determined at $p < 0.05$, and exact p-values were reported. The effect-size analysis was included to determine the practical magnitude of group differences rather than relying solely on statistical significance. Effect sizes were interpreted as small, moderate, or large based on commonly applied criteria. The unequal gender distribution was considered when interpreting the magnitude and precision of gender-related effects.

The comparisons were formulated based on the research questions and involved two related outcome variables across three demographic characteristics. Bonferroni correction was not applied because it can be overly conservative when statistical comparisons are theoretically related, potentially increasing the risk of Type II error in exploratory research Armstrong (2014). To reduce the possibility of overinterpretation, the conclusions considered exact p-values, effect sizes, theoretical relevance, and consistency across the analyses. However, the absence of a family-wise error adjustment increases the possibility of Type I error, particularly for results with p-values close to 0.05. Future studies may use alternative procedures, such as the False Discovery Rate adjustment. Simple linear regression was used to examine whether environmental knowledge statistically predicted environmental care attitudes. Environmental knowledge was entered as the independent variable, while environmental care attitudes were entered as the dependent variable. Before interpretation, regression assumptions concerning linearity, independence of residuals, homoscedasticity, influential observations, and residual distribution were examined.

The unstandardized regression coefficient was interpreted as the expected unit change in the environmental attitude score associated with a one-unit increase in the environmental knowledge score. For example, a coefficient of (B = 0.39) indicates an expected increase of 0.39 score units in environmental attitudes for every one-unit increase in environmental knowledge. It does not represent a 39% increase. The coefficient of determination, (R^2), was used to determine the proportion of variance in environmental care attitudes statistically explained by environmental knowledge.

Because the study used a cross-sectional design, the regression findings indicate a statistical association or predictive contribution rather than a causal relationship. Therefore, causal expressions such as environmental knowledge “causes” or definitively “improves” environmental attitudes were avoided. The model also did not control for potential confounding variables, including socioeconomic background, family environmental practices, motivation, social norms, participation in environmental organizations, campus culture, and previous environmental experiences. These unmeasured variables may partly explain the relationship between environmental knowledge and environmental care attitudes.

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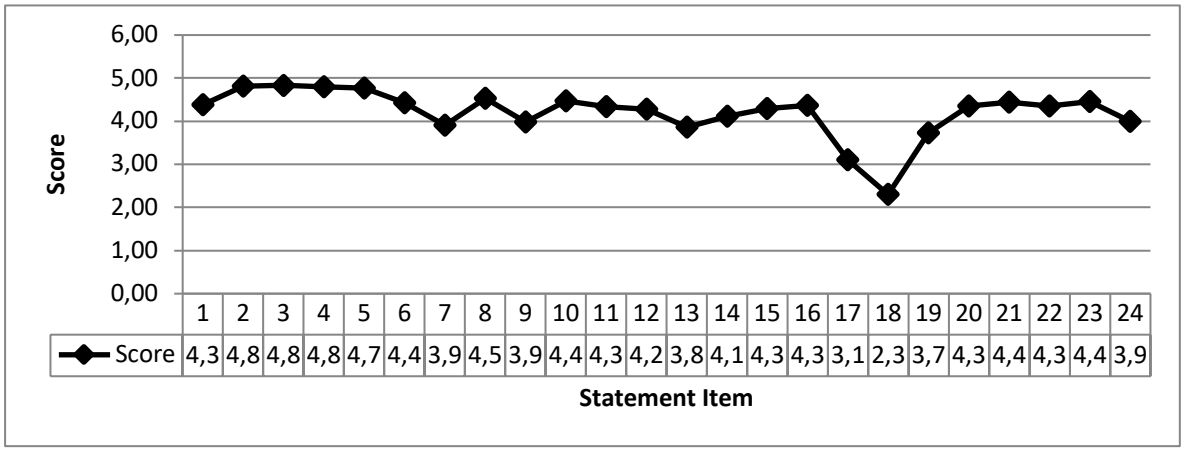
The study did not triangulate questionnaire findings through interviews, observations, or direct behavioural measurements. Consequently, the analysis provides a broad quantitative description but cannot fully explain why students possess particular levels of environmental knowledge or attitudes. Future studies should use stratified or probability sampling across multiple universities, establish more balanced demographic groups, calculate response rates, improve instrument validity, control relevant confounding variables, and combine surveys with qualitative or behavioural data.

3. RESULTS

Description of Environmental Knowledge and Care Attitudes

Descriptive analysis was conducted to examine students' environmental knowledge and environmental care attitudes. The overall mean environmental knowledge score was 53.35, which was classified as high based on the predetermined scoring criteria. In contrast, the overall mean environmental care attitude score was 47.07, which was classified as moderate. This difference indicates that students' relatively high environmental knowledge was not fully accompanied by an equally high level of environmental care attitudes. Figure 1 presents the mean scores for the 24 questionnaire statements. Statements 2, 3, and 4 obtained the highest mean scores of 4.8. These results indicate that students demonstrated a strong understanding of environmental cleanliness, handwashing practices, and environmental responsibility in the post-pandemic context. Statement 18 obtained the lowest raw mean score of 2.3. Because Statement 18 was negatively worded, the low score indicates respondents' disagreement with indifference toward individuals who neglect environmental cleanliness. Therefore, this result reflects environmental concern rather than a low level of environmental awareness. All negatively worded statements were reverse-scored before the composite scores were calculated.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Score	4,3	4,8	4,8	4,8	4,7	4,4	3,9	4,5	3,9	4,4	4,3	4,2	3,8	4,1	4,3	4,3	3,1	2,3	3,7	4,3	4,4	4,3	4,4	3,9

Figure 1. *Mean Score Distribution Across Questionnaire Items*

Figure 2 presents the mean environmental knowledge and attitude scores according to gender, year of study, and academic discipline. Female students obtained higher mean scores for environmental knowledge and environmental care attitudes than male students. The mean knowledge score was 53.95 among female students and 52.14 among male students. Similarly, the mean attitude score was 48.11 among female students and 45.02 among male students. Based on year of study, first-year students obtained a slightly higher mean knowledge score than second-year students, with scores of 53.57 and 53.45, respectively.

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First-year students also obtained a higher mean attitude score of 47.63, compared with 47.02 among second-year students. However, the descriptive differences between the two groups were relatively small. Students from the Social Science group obtained a mean environmental knowledge score of 53.56, while Natural Science students obtained a mean score of 53.45. The mean environmental care attitude score was 47.49 among Social Science students and 47.15 among Natural Science students. These descriptive results indicate only minor differences between the two academic disciplines.

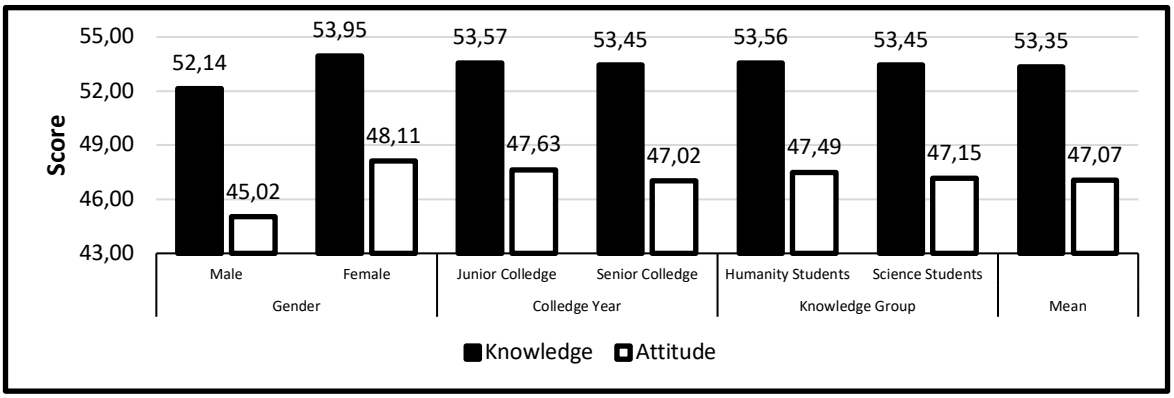

Figure 2. *Mean Environmental Knowledge and Care Attitude Scores by Demographic Group*

Differences in Environmental Knowledge and Care Attitudes

Table 5 presents the differences in environmental knowledge and environmental care attitudes based on gender, college year, and academic discipline. Statistically significant differences were identified only for gender. Female students had a higher mean rank for environmental knowledge (288.20) than male students (229.37), with a Mann-Whitney U value of 21,499.00 and a p-value of 0.01. Female students also had a higher mean rank for environmental care attitudes (294.09) than male students (210.84), with a Mann-Whitney U value of 19,053.50 and a p-value of 0.01. These findings indicate that female students demonstrated significantly higher environmental knowledge and environmental care attitudes than male students.

Regarding college year, first-year students had a slightly higher mean rank for environmental knowledge (275.82) than second-year students (271.60). However, this difference was not statistically significant, (U = 36,132.00), (p = 0.76). First-year students also had a higher mean rank for environmental care attitudes (279.91) than second-year students (266.22), but the difference was not statistically significant, (U = 34,861.50), (p = 0.31). Therefore, no significant differences in environmental knowledge or environmental care attitudes were found between the 271 first-year students and 276 second-year students.

Based on academic discipline, Natural Science students had a slightly higher mean rank for environmental knowledge (274.11) than Social Science students (273.93). However, the difference was not statistically significant, (U = 34,750.50), (p = 0.99). In contrast, Social Science students had a higher mean rank for environmental care attitudes (277.82) than Natural Science students (267.43), but this difference was also not statistically significant, (U = 33,453.00), (p = 0.45). Thus, no significant differences in environmental knowledge or environmental care attitudes were identified between the 223 Social Science students and 324 Natural Science students. Overall, gender was the only demographic characteristic

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associated with statistically significant differences in both environmental knowledge and environmental care attitudes.

Table 5. *Mann-Whitney U Test Results for Environmental Knowledge and Care Attitudes*

Grouping Indicator	Variable	Group	N	Mean Rank	Mann-Whitney U	p-value
Gender	Knowledge	Male	132	229.37	21499.00	0.01
		Female	415	288.20		
	Attitudes	Male	132	210.84	19053.50	0.01
		Female	415	294.09		
College Year	Knowledge	First-year College	271	275.82	36132.00	0.76
		Second-year College	276	271.60		
	Attitudes	First-year College	271	279.91	34861.50	0.31
		Second-year College	276	266.22		
Academic Discipline	Knowledge	Social Science	223	273.93	34750.50	0.99
		Natural Science	324	274.11		
	Attitudes	Social Science	223	277.82	33453.00	0.45
		Natural Science	324	267.43		

Note: Statistical significance was determined at $p<0.05$.

Association Between Environmental Knowledge and Students' Environmental Care Attitudes

The regression analysis presented in Table 6 shows a positive and statistically significant association between environmental knowledge and environmental care attitudes. The model produced an Rvalue of 0.26 and an R^2value of 0.07. More precisely, environmental knowledge explained approximately 6.6% of the variance in students' environmental care attitudes. The regression model was statistically significant, $F = 38.54$, $p = 0.01$. Although environmental knowledge was significantly associated with environmental care attitudes, the explanatory power of the model was relatively small. Approximately 93.4% of the variance in environmental care attitudes was associated with other factors not included in the model. These factors may include personal values, motivation, social norms, environmental experiences, peer influence, and campus culture. Therefore, environmental knowledge represents one relevant predictor but does not fully explain students' environmental care attitudes.

Table 6. *Regression Model Summary for Environmental Knowledge and Care Attitudes*

Model	R	R^2	F	p-value
Knowledge → Attitudes	0.26	0.07	38.54	0.01

Figure 3 presents the Normal P-P Plot of Regression Standardized Residuals for environmental care attitudes. Most data points were distributed close to the diagonal reference line, although minor deviations were observed, particularly at the tails. This pattern indicates that the regression residuals were approximately normally distributed. Therefore, the residual normality assumption was reasonably satisfied. However, the P-P plot only assesses the normality of residuals and does not independently demonstrate the linearity or homoscedasticity of the regression model.

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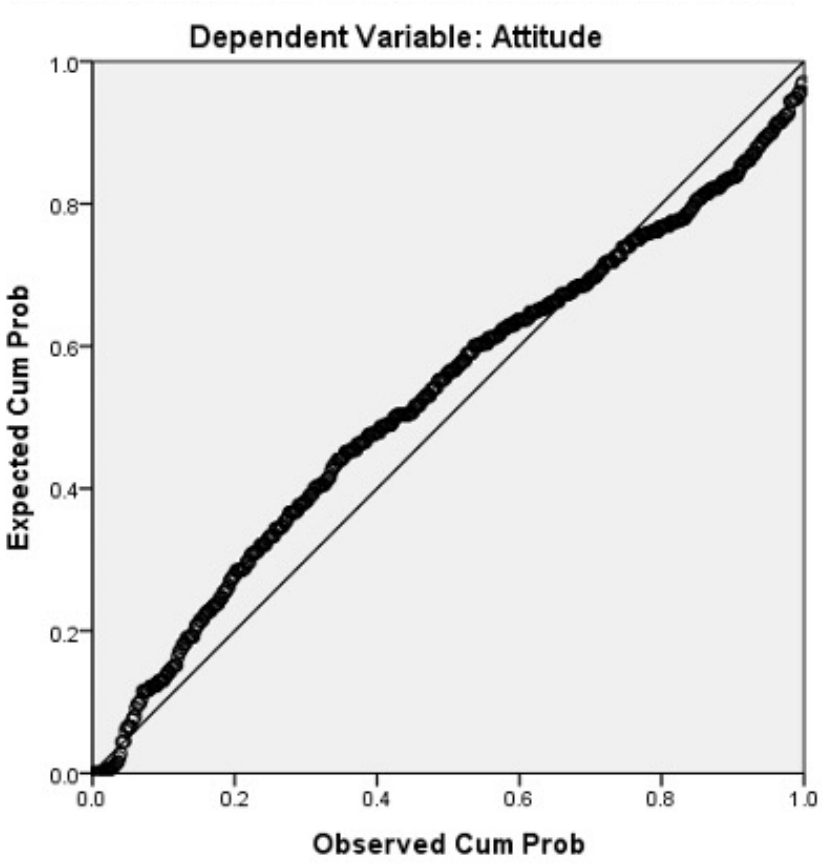

Figure 3. *Normal P-P Plot of Regression Standardized Residuals*

The regression coefficients are presented in Table 7. Environmental knowledge had a positive and statistically significant coefficient, $B = 0.39$, $SE = 0.06$, $\beta = 0.26$, $t = 6.21$, $p = 0.01$. The resulting regression equation was:

$$\text{Environmental Care Attitudes} = 26.45 + 0.39(\text{Environmental Knowledge})$$

Table 7. Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error (B)	(Beta)		
1	(Constant)	26.45	3.38		7.83	0.01
	Knowledge	0.39	0.06	0.26	6.21	0.01

The unstandardized coefficient indicates that each one-unit increase in the environmental knowledge score was associated with an estimated increase of 0.39 units in the environmental care attitude score. The coefficient does not indicate a 39.1% improvement. The standardized coefficient of $\beta = 0.26$indicates a small positive association. Because the study employed a cross-sectional design, these findings demonstrate a statistical association and predictive contribution rather than a causal relationship.

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4. DISCUSSION

Levels of Environmental Knowledge and Environmental Care Attitudes

The findings show that students at the University of Riau had a high level of environmental knowledge but only a moderate level of environmental care attitudes. This difference indicates a gap between students' understanding of environmental issues and their affective orientation toward environmental protection. Students may understand environmental cleanliness, health protection, waste management, and sustainability, but such knowledge does not automatically produce equally strong concern, responsibility, or willingness to participate in environmental action.

This finding supports previous studies showing that environmental knowledge provides an important cognitive foundation for developing positive environmental attitudes (Bradley et al., 1999; Kuhlemeier et al., 1999; Gökmen, 2021; Müderrisoglu & Altanlar, 2011; Sasea et al., 2023). Ruhimat & Ruhimat (2021) similarly identified a positive relationship between environmental knowledge and attitudes, although the contribution of knowledge was limited. Therefore, environmental awareness should not be understood only as the possession of information. It also involves personal values, emotional engagement, social responsibility, environmental experience, and opportunities to participate in sustainability activities.

The moderate attitude level may reflect the limitations of environmental education that emphasizes information transmission more strongly than practical engagement. Palmer et al. (1999) argue that environmental concern develops through the integration of knowledge and meaningful experiences. Repeated participation in environmental activities can strengthen students' commitment to sustainability (DiEnno & Hilton, 2005; Koruoglu et al., 2015). Universities should therefore connect classroom knowledge with practical activities, including waste audits, energy-saving projects, environmental campaigns, biodiversity monitoring, and community-based conservation programs.

The post-pandemic context also provides an important interpretation. The pandemic increased attention to environmental health, personal hygiene, waste management, and resource conservation (Matiiuk & Liobikienė, 2023; Fiske et al., 2024). However, temporary environmental improvements during mobility restrictions diminished after normal activities resumed. This condition suggests that crisis-related awareness may not develop into long-term environmental commitment without sustained educational and institutional support. The findings therefore emphasize the need for environmental education that integrates cognitive, affective, social, and experiential dimensions.

First-year students had slightly higher environmental knowledge and care attitudes than second-year students, but the differences were not significant. This aligns with Purnamasari et al. (2019), while Hadi et al. (2023) suggest that recent coursework or personal experiences may explain the higher first-year scores. However, because the study compared only two academic-year groups, longitudinal research is needed to assess the cumulative effect of university education.

Academic discipline also showed no significant differences. Although Social Science and Natural Science students had slightly different scores, the broad grouping may conceal variations in curriculum and environmental learning across individual programs Nzengya & Rutere (2021), Overall, significant differences appeared only by gender, with female students showing higher knowledge and care attitudes. Future studies should examine curriculum content, environmental program participation, personal experience, and socialization.

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Differences Based on Gender, Duration of Study, and Academic Discipline

Significant differences were found based on gender, with female students demonstrating higher environmental knowledge and environmental care attitudes than male students. These findings are consistent with Ahmad et al. (2015), Ami et al. (2022), Gökmen (2021), Mursyd et al. (2023), Müderrisoglu & Altanlar (2011), Setiawan et al. (2023), and Zulkarnaen et al. (2023), who reported stronger environmental concern or responsibility among women.

Previous studies have associated gender differences with academic achievement, cognitive flexibility, empathy, and responsibility. Voyer & Voyer (2014) reported variations in academic performance, while Wang & Degol (2017) discussed differences in educational and occupational orientations. Male students have also been associated with specialized areas such as STEM, spatial thinking, and waste management (Aliman et al., 2020). Nevertheless, these differences should not be interpreted as fixed or biologically determined characteristics. The contrasting findings of Arcury et al. (1987), who reported lower environmental knowledge among women, demonstrate that gender differences depend on social, historical, and educational contexts.

In Indonesia, including Riau, gendered socialization may influence environmental awareness. Male and female students may experience different expectations related to household cleanliness, health protection, community care, and environmental responsibility. These experiences may shape access to environmental information and the expression of concern. However, the present study did not directly measure cultural expectations, family roles, or participation in environmental organizations. These factors should therefore be treated as possible explanations rather than conclusions. The gender imbalance in the sample also requires cautious interpretation.

Universities should not use these findings to reinforce gender stereotypes. Instead, environmental programs should provide inclusive opportunities for all students. Male participation may be strengthened through technology-based environmental monitoring, waste-management innovation, outdoor conservation, project competitions, and mixed-gender sustainability teams. Such approaches can increase engagement while avoiding assumptions that environmental responsibility belongs more strongly to one gender.

No significant differences were found between first-year and second-year students. This finding is consistent with Purnamasari et al. (2019), who showed that participation in environmental education did not always produce significant differences in environmental care attitudes. Hadi et al. (2023) suggest that students' environmental understanding may be influenced by recent coursework or personal experiences. Knowledge and attitudes can also develop through family practices, social interaction, extracurricular activities, media exposure, motivation, and daily experiences (Orbanić & Kovač, 2021). However, the result does not prove that duration of study has no effect. The analysis only compared first-year and second-year students, whose difference in academic exposure may be insufficient to reveal cumulative educational effects. A comparison involving final-year students might produce different results. Longitudinal research is therefore needed to observe changes from university entry to graduation.

Academic discipline also produced no significant differences. Natural Science students had slightly higher environmental knowledge, while Social Science students had slightly higher environmental care attitudes. Exposure to ecology, environmental science, and resource management may support knowledge among Natural Science students (Fytopoulou et al., 2023; Nikolic et al., 2020; Situmorang et al., 2020). Social Science students may approach environmental issues through ethics, empathy, social justice, and community perspectives (Cruz & Natividad-Franco, 2021; Nzengya & Rutere, 2021).

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Nevertheless, grouping ten faculties into only Social Science and Natural Science categories may conceal substantial curricular differences. Engineering, medicine, agriculture, nursing, fisheries, education, economics, and law provide different forms of environmental learning. Because the study did not analyse faculty curricula, teaching strategies, or environmental course content, the findings should not be interpreted as evidence that all disciplines provide similar educational experiences. Environmental knowledge and attitudes should instead be treated as cross-disciplinary competencies (Yusmantara, 2011; Kapan & Yardımcı Gürel, 2022). Universities should map sustainability content across faculties and establish shared environmental learning outcomes adapted to each discipline.

The Impact of Environmental Knowledge on Environmental Care Attitudes

Environmental knowledge was positively and significantly associated with environmental care attitudes. Students with greater knowledge tended to show stronger environmental concern, consistent with Bradley et al. (1999), Gökmen, (2021), Kuhlemeier et al. (1999), Müderrisoglu & Altanlar (2011), Ruhimat & Ruhimat (2021), Sasea et al. (2023). However, knowledge explained only 6.6% of the variation in attitudes, indicating that it was a statistically significant but weak predictor.

The limited explanatory power suggests that environmental attitudes are also shaped by values, social norms, institutional culture, emotional involvement, personal experience, and perceived responsibility (Afsar et al., 2016; Cologna et al., 2024; Colombo et al., 2023; Demetriou et al., 2024; Hansla et al., 2008; Prinzing et al., 2024). Environmental behaviour therefore develops through interactions among cognitive, personal, and contextual factors (Huang 2024; Orbanić & Kovač, 2021). This finding also highlights the limitation of a linear knowledge-attitude-practice model. Students may possess environmental knowledge and positive attitudes but fail to act because of limited facilities, weak social support, competing priorities, or situational barriers (Handoyo et al., 2016; Dlamini et al., 2020).

Environmental concern can be strengthened when knowledge is combined with meaningful and repeated experiences (Palmer et al., 1999). Participation in environmental activities can promote sustained engagement and responsibility (DiEnno & Hilton, 2005; Koruoglu et al., 2015). This is particularly relevant in the post-pandemic context, where concerns about climate change, waste management, and resource conservation influenced daily practices, although temporary environmental improvements during lockdowns declined after normal activities resumed (Matiiuk & Liobikienė, 2023; Fiske et al., 2024).

Universities should therefore integrate environmental knowledge with values-based education, experiential learning, collaborative projects, and institutional sustainability policies (Wang & Zhang, 2021). Future studies should apply longitudinal designs, multiple regression, mediation analysis, moderation analysis, or structural equation modelling to examine the roles of subjective norms, perceived behavioural control, personal values, self-efficacy, and institutional factors in shaping environmental care attitudes and sustainable behaviour.

5. CONCLUSION AND IMPLICATIONS

This study concludes that students at the Universitas Riau possess high environmental knowledge but only moderate environmental care attitudes. Environmental knowledge has a significant positive effect on attitudes, although the effect is small. Female students show higher knowledge and environmental care attitudes than male students, while no significant differences are found based on study duration or academic discipline. These findings indicate

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that knowledge alone is insufficient to produce strong pro-environmental attitudes because motivation, social norms, personal experience, self-efficacy, and campus culture may also play important roles. Theoretically, this study supports the knowledge-attitude relationship in environmental education while showing that cognitive factors should be integrated with affective, social, and experiential dimensions. Practically, universities should embed environmental learning outcomes in courses, student activities, and campus programs. Suggested actions include waste audits, energy-saving campaigns, biodiversity monitoring, community-based projects, and inclusive activities designed to reduce gender disparities. Program success may be assessed through attitude scores, participation rates, project completion, and measurable changes in environmental behaviour.

This study is limited by its cross-sectional design, self-reported data, single-institution setting, and the time gap between data collection and publication. Therefore, the findings represent conditions during the study period and may not fully reflect current student attitudes. Future research should use longitudinal, experimental, or mixed-method designs across multiple universities. It should also examine motivation, environmental self-efficacy, social norms, peer influence, digital media exposure, and campus sustainability culture as mediating or moderating variables. Behavioural observations should complement questionnaires to determine whether environmental knowledge translates into consistent sustainable practices.

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