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Turning Chemistry into Care: Building Environmental Sensitivity Through Atmospheric Chemistry

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Abstract- ***The escalating severity of environmental issues such as air pollution, climate change, and ozone depletion underscores the urgent need for effective environmental education that fosters both scientific understanding and affective responsibility among learners. In this context, Atmospheric Chemistry provides a critical framework for understanding the underlying mechanisms of these environmental challenges. However, conventional instructional approaches often fail to meaningfully connect scientific concepts with students lived experiences, thereby limiting the development of Environmental Sensitivity. The present study aimed to develop and evaluate an Instructional Module on Atmospheric Chemistry for enhancing Environmental Sensitivity among secondary school students. A pre-experimental design employing a single-group pre-test–post-test approach was adopted. The sample comprised 41 secondary school students selected through simple random sampling. The investigator developed an Instructional Module that served as the independent variable, while Environmental Sensitivity was treated as the dependent variable and measured using a standardised Environmental Sensitivity Test. Data were analysed using descriptive statistics, a paired-samples t-test, and repeated measures ANOVA to determine the significance of differences between pre-test and post-test scores. The results indicated a statistically significant improvement in students' Environmental Sensitivity following the intervention. Furthermore, all dimensions of Environmental Sensitivity - cognitive awareness, emotional responsiveness, adaptive plasticity, and behavioural commitment demonstrated substantial enhancement. The study concludes that integrating Atmospheric Chemistry with experiential and value-based pedagogical strategies effectively promotes Environmental Sensitivity among students. The findings highlight the potential of subject-specific Instructional Modules to strengthen environmental education and foster the development of responsible, environmentally conscious individuals.***

Keywords: ***Atmospheric Chemistry, Environmental Sensitivity, Instructional Module, Cognitive Awareness, Emotional Responsiveness, Adaptive Plasticity, And Behavioural Commitment.***

I. INTRODUCTION

Learning about air pollution and climate change should inspire students to take real responsibility for the environment. However, although environmental challenges such as air pollution, climate change, and ozone depletion are urgent global concerns affecting ecosystems, human health, and sustainable development, Atmospheric Chemistry concepts are often taught in a purely theoretical manner, limiting students' ability to connect knowledge with real-life action. Environmental Sensitivity, which includes emotional, cognitive, and behavioural responsiveness toward environmental issues, is essential for bridging the gap between knowledge and action [3]. Despite educational reforms such as the National Education Policy,2020 [8] promoting experiential and value-based learning, there remains a lack of structured, subject-specific approaches that effectively integrate science with environmental responsibility. This study addresses this need by developing an Instructional Module on Atmospheric Chemistry aimed at transforming scientific understanding into meaningful, real-world environmental action among secondary school students.

Need and Significance of the Study

Today's students are growing up in a world where climate change, polluted air, and extreme weather events are lived realities, yet many lack a clear understanding of the scientific processes behind these changes, particularly the chemical reactions occurring in the atmosphere. This disconnect between knowledge and real-life experience limits their emotional engagement with environmental issues and reduces their sense of responsibility. When

Atmospheric Chemistry is taught as abstract and unrelated to everyday life, it fails to make learning meaningful and transformative, highlighting the need for more relevant and context-based instruction. Understanding the chemical basis of environmental problems can help students connect scientific concepts with real-world situations and recognise their role in environmental protection, thereby fostering Environmental Sensitivity, which includes awareness, emotional concern, adaptability, and responsible behaviour [3]. However, traditional teaching methods often separate scientific knowledge from value-based learning, creating a gap between knowledge and action. Despite the growing emphasis on experiential learning, there remains a lack of structured, subject-specific instructional materials that integrate science with environmental responsibility. Therefore, the present study is significant as it aims to develop and evaluate an Atmospheric Chemistry Module to enhance Environmental Sensitivity among secondary school students and promote meaningful, real-world learning.

II. REVIEW OF LITERATURE

Previous studies on Environmental Sensitivity have emphasized its importance in shaping environmentally responsible behaviour among learners, with research by Sakarya et al.[10] , Wigley et al. [12], and Kement et al. [7] highlighting the role of emotional engagement, nature connectedness, and experiential learning in fostering pro-environmental attitudes and actions. Similarly, studies by Demir et al. [5] and Amin et al. [2] confirm that activity-based and problem-based learning approaches significantly enhance Environmental Sensitivity compared to traditional methods. In contrast, research on Atmospheric Chemistry by Allen et al. [1] , Ram [9], Davis et al. [4] , Kern [6] , and Sharma [11] primarily focuses on improving students' conceptual understanding of environmental issues such as climate change, air pollution, and ozone depletion, with limited emphasis on affective and behavioural outcomes. A critical analysis of the literature reveals a clear research gap, as Environmental Sensitivity and Atmospheric Chemistry have largely been studied separately, with minimal integration of scientific understanding and emotional or behavioural learning, particularly at the secondary school level. Moreover, the effectiveness of subject-specific Instructional Modules in enhancing Environmental Sensitivity has not been sufficiently explored. This gap justifies the present study, which aims to develop and evaluate an Atmospheric Chemistry Module that integrates cognitive, emotional, and behavioural dimensions to enhance Environmental Sensitivity among secondary school students.

Research Questions

1. How effective is the Atmospheric Chemistry Module in improving the Environmental Sensitivity of secondary school students?
2. Is there a significant difference in the effectiveness of the Atmospheric Chemistry Module across different components of Environmental Sensitivity?

Objectives of the Study

1. To examine the effectiveness of the Atmospheric Chemistry Module on Environmental Sensitivity among secondary school students.
2. To analyse the effectiveness of the Module on different components of Environmental Sensitivity.
3. To determine whether there is a significant difference in Environmental Sensitivity based on its components.

Hypotheses of the Study

1. The Atmospheric Chemistry Module has a significant effect on Environmental Sensitivity among secondary school students.
2. The Atmospheric Chemistry Module has a significant effect on the components of Environmental Sensitivity.
3. There is no significant difference in the effectiveness of the Atmospheric Chemistry Module across the components of Environmental Sensitivity.

III. METHODOLOGY

Research Method: The study adopted an experimental method to develop and evaluate the effectiveness of an Instructional Module on

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Atmospheric Chemistry in enhancing Environmental Sensitivity among secondary school students.

Research Design: A pre-experimental, single-group pre-test–post-test design was employed to assess the impact of the intervention.

Sample: The population of the study comprised secondary school students. The sample consisted of 41 Standard VIII students selected from a secondary school in Pathanamthitta District, Kerala, using a simple random sampling technique.

Materials and Tools: The study utilised an investigator-developed Instructional Module on Atmospheric Chemistry, along with lesson transcripts and a standardised Environmental Sensitivity Test. The test included objective-type items designed to measure four dimensions of Environmental Sensitivity: cognitive awareness, emotional responsiveness, adaptive plasticity, and behavioural commitment.

Statistical Techniques: The collected data were analysed using descriptive statistics, a paired-samples t-test to determine the significance of differences between pre-test and post-test scores, and analysis of variance (ANOVA) to examine differences across the components of Environmental Sensitivity.

Procedure of Experiment

The experiment was conducted in three phases: pre-test, treatment, and post-test. A pre-test was administered to assess the baseline level of Environmental Sensitivity. This was followed by the implementation of the Instructional Module through structured lessons, activities, and interactive teaching strategies. After the intervention, a post-test was conducted using the same instrument to measure changes in Environmental Sensitivity. Only the responses of students who completed both tests were included for analysis.

IV. RESULTS

The effectiveness of the Instructional Module on Atmospheric Chemistry on Environmental Sensitivity and its components among Secondary School Students is presented in Table 1 and Figure 1.

Table 1 Effectiveness of the Atmospheric Chemistry Module on Environmental Sensitivity and Its Components

Variable	Test	N	Mean	SD	t-value	df	p	Cohen's d
Environmental Sensitivity	Pre-test	41	16.41	4.67	16.04	40	< .001	2.51
	Post- test	41	30.59	4.01				
Cognitive Awareness	Pre-test	41	6.22	1.22	14.28	40	< .001	2.23
	Post- test	41	9.34	0.94				
Emotional Responsiveness	Pre-test	41	3.85	2.08	8.81	40	< .001	1.38
	Post- test	41	7.44	1.70				
Adaptive Plasticity	Pre-test	41	3.07	1.52	11.22	40	< .001	1.75
	Post- test	41	6.88	1.65				
Behavioural Commitment	Pre-test	41	3.27	1.38	12.74	40	< .001	1.99
	Post- test	41	6.93	1.63				

The results presented in Table 1 indicate a substantial improvement in Environmental Sensitivity among

secondary school students following the implementation of the Atmospheric Chemistry Instructional Module. The mean score of overall Environmental Sensitivity increased markedly from 16.41 (SD = 4.67) in the pre-test to 30.59 (SD = 4.01) in the post-test. The paired-samples t-test revealed that this difference was statistically significant ($t(40) = 16.04$, $p < .001$), with a very large effect size (Cohen's $d = 2.51$), indicating a strong impact of the intervention.

A similar pattern of significant improvement was observed across all components of Environmental Sensitivity. Cognitive awareness showed a significant increase from a mean of 6.22 to 9.34 ($t = 14.28$, $p < .001$, $d = 2.23$), reflecting enhanced conceptual understanding of environmental issues. Emotional responsiveness improved from 3.85 to 7.44 ($t = 8.81$, $p < .001$, $d = 1.38$), indicating heightened affective engagement. Adaptive plasticity increased from 3.07 to 6.88 ($t = 11.22$, $p < .001$, $d = 1.75$), suggesting improved flexibility in attitudes and willingness to adapt environmentally responsible behaviours. Behavioural commitment also showed significant growth from 3.27 to 6.93 ($t = 12.74$, $p < .001$, $d = 1.99$), demonstrating a stronger inclination toward pro-environmental actions. The consistently high t-values, statistically significant p-values, and large effect sizes across all variables confirm the effectiveness of the Instructional Module.

The findings of the study clearly demonstrate that the Atmospheric Chemistry Instructional Module was highly effective in enhancing Environmental Sensitivity among secondary school students. The significant improvement in cognitive awareness suggests that integrating Atmospheric Chemistry concepts enabled students to better understand the scientific basis of environmental issues such as air pollution and climate change. This supports the view that subject-specific contextualization strengthens conceptual learning.

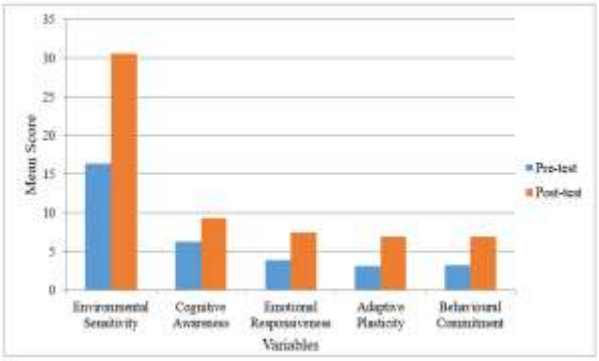
The notable gains in emotional responsiveness indicate that the Module successfully engaged students at the affective level, fostering concern and empathy towards environmental issues. This may be attributed to the inclusion of experiential and value-based learning strategies, which are known to bridge the gap between knowledge and emotional engagement.

Improvements in adaptive plasticity and behavioural commitment further highlight the Module's effectiveness in promoting attitudinal and behavioural change. These findings suggest that when learners are provided with meaningful, context-rich learning experiences, they are more likely to internalize environmental values and translate them into responsible actions.

The large effect sizes across all components reinforce the practical significance of the intervention, indicating that the Instructional Module was not only statistically effective but also educationally impactful. The results align with contemporary perspectives in environmental education that emphasise the integration of cognitive, affective, and behavioural domains for holistic development.

The Instructional Module on Atmospheric Chemistry is highly effective in enhancing Environmental Sensitivity among secondary school students. The intervention brought about significant improvements in all dimensions of Environmental Sensitivity - cognitive awareness, emotional responsiveness, adaptive plasticity, and behavioural commitment, with large effect sizes indicating strong practical significance.

Figure 1 Effectiveness of the Atmospheric Chemistry Module on Environmental Sensitivity and Its Components



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The significant difference in the effectiveness of the Atmospheric Chemistry Module across the components of Environmental Sensitivity is presented in Table 2.

Table 2.

Significant Difference in the Effectiveness of the Atmospheric Chemistry Module Across the Components of Environmental Sensitivity

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Components	10.70	3	3.57	1.21	.31	0.03

The results presented in the table indicate the effectiveness of the Atmospheric Chemistry Instructional Module across the components of Environmental Sensitivity among secondary school students. The one-way ANOVA results show that the sum of squares between the components is 10.70 with 3 degrees of freedom, resulting in a mean square value of 3.57. The obtained F-value ($F = 1.21$) is not statistically significant at the 0.05 level ($p = .31$), indicating that there is no significant difference in the effectiveness of the Instructional Module across the different components. The effect size, as indicated by partial eta squared ($\eta^2p = 0.03$), is small, suggesting that the variation in scores among the components is minimal.

The findings reveal that there is no statistically significant difference in the impact of the Instructional Module on cognitive awareness, emotional responsiveness, adaptive plasticity, and behavioural commitment. Although slight variations in the mean scores of these components may exist, the differences are not statistically meaningful. The low F-value, non-significant p-value, and small effect size collectively indicate that the Instructional Module does not differentially influence any specific component of Environmental Sensitivity.

The findings of the study clearly demonstrate that the Atmospheric Chemistry Instructional Module ensures a uniform level of effectiveness across all components of Environmental Sensitivity. The absence of significant differences suggests that the Module equally supports the development of cognitive understanding, emotional engagement, adaptive attitudes, and behavioural commitment towards environmental issues.

The consistent impact across all components indicates that the Instructional Module successfully integrates multiple dimensions of Environmental Sensitivity, thereby promoting balanced and holistic development among learners. This highlights the effectiveness of the Module in addressing environmental education in a comprehensive manner without favouring any particular domain.

The Instructional Module on Atmospheric Chemistry is equally effective across all components of Environmental Sensitivity, with no significant differences observed among cognitive awareness, emotional responsiveness, adaptive plasticity, and behavioural commitment, indicating a uniform and holistic impact of the intervention.

V. MAJOR FINDINGS OF THE STUDY

- The Instructional Module on Atmospheric Chemistry resulted in a statistically significant and substantial improvement in overall Environmental Sensitivity among secondary school students, with a very large effect size.
- The Instructional Module on Atmospheric Chemistry resulted in a statistically significant all components of Environmental Sensitivity - cognitive awareness, emotional responsiveness, adaptive plasticity, and behavioural commitment showed significant enhancement, reflecting improvement in students' knowledge, attitudes, emotional engagement, and pro-environmental behaviour.
- The large effect sizes across all components indicate that the Instructional Module was not only statistically significant but also educationally impactful in promoting Environmental Sensitivity.

- There is no significant difference in the effectiveness of the Module across different components of Environmental Sensitivity, indicating that the intervention influenced all dimensions uniformly.
- The Instructional Module ensured a balanced and holistic development of Environmental Sensitivity by integrating cognitive, affective, and behavioural domains.

Educational Implications

- Atmospheric Chemistry concepts can be effectively integrated into the school curriculum to enhance students' Environmental Sensitivity.
- Subject-specific Instructional Modules can serve as effective tools for linking scientific knowledge with real-life environmental issues.
- Science teaching should focus on conceptual clarity along with real-world applications related to environmental problems.
- Learning experiences should integrate cognitive, emotional, adaptive, and behavioural dimensions for holistic development.
- Activity-based and experiential learning approaches are essential for fostering Environmental Sensitivity.
- Classroom instruction should include discussions, case studies, and reflective activities to develop environmental concern and empathy.
- Teaching strategies should promote adaptability and problem-solving skills to address environmental challenges.
- Environmental education should emphasize responsible action and sustainable practices, not just awareness.
- Teacher training programs should incorporate innovative strategies for teaching environmental concepts effectively.
- Schools should promote student participation in environmental activities to strengthen behavioural commitment toward environmental protection

VI. CONCLUSION

The study establishes that the Instructional Module on Atmospheric Chemistry is highly effective in enhancing Environmental Sensitivity among secondary school students. The intervention resulted in significant improvements across cognitive, emotional, attitudinal, and behavioural dimensions, with strong effect sizes indicating substantial educational impact. The absence of differential effects across components further confirms the Module's ability to promote balanced, holistic development. These findings highlight the importance of integrating subject-specific content with experiential and value-based approaches in environmental education, thereby fostering environmentally responsible and conscious learners.

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