

The Mediating Role of Environmental Awareness in the Relationship between Environmental Education and Climate Change Preparedness among University Students

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Research Article

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Abstract

Climate change increasingly threatens vulnerable regions such as Bangladesh, making university students' preparedness for environmental risks a pressing concern. This study examined whether environmental awareness mediates the relationship between environmental education and climate change preparedness among 380 university students and explored demographic differences in environmental education, environmental awareness, and climate change preparedness. Using Hayes' PROCESS Model 4 with 5,000 bootstrap resamples, results showed that environmental education significantly predicted environmental awareness ($\beta = .431, p < .001$), which in turn significantly predicted preparedness ($\beta = .589, p < .001$). The indirect effect confirmed that awareness mediates this relationship, as the direct effect of education on preparedness remained significant ($\beta = .246$) despite the substantial reduction from the total effect ($\beta = .500$). Demographic comparisons revealed no significant differences by gender, department, or residential area, whereas formal coursework enrollment, climate event participation, and year of study significantly differentiated outcomes, with senior and postgraduate students showing the strongest awareness and preparedness. These findings highlight environmental awareness as a critical psychological pathway linking education to action, with direct implications for climate-focused curriculum design in higher education.

1. INTRODUCTION

Climate change is basically a human cause problem. Human activities have increasingly endangered climate systems day by day, which hamper well-being and creating a serious issue for human survival on planet (Koley, 2020; Pillay & Van Den Bergh, 2016). It is well supported through scientific evidence that the climate of the world goes worsen day by day and (IPCC, 2014; O'Brien, 2013). If we do not change this trend, future generations will suffer more frequent and severe natural disasters.

This issue is a living reality in the present time, so the scientists are no longer debating this matter and acknowledge it worldwide. Climate skepticism has been notable in many public discourses, but global consensus among climate scientists suggests anthropogenic climate change can be determined "beyond reasonable doubt" (Douglas & Sutton, 2015). This has been corroborated by multiple reports from the Intergovernmental Panel on Climate Change indicating 0.3–0.6°C of warming globally mean surface temperature in the last hundred years, and possibly another 1.4–5.8°C in a further hundred years (IPCC, 2014). At the same time, sea levels across the globe are rising 1.8 mm a year and Arctic-sea ice is declining at 2.7% per decade (IPCC, 2014). These numbers are not just statistics; they also represent the real impact of earth caused mainly by human. Climate change threatens all aspects of human life food and water security, energy production, health, economic activity and international migration (Nelson et al., 2014). In addition to human systems, it threatens natural ecosystems-changing the species living pattern, altering seasonal cycle, when they do so and the composition of communities (Franco et al., 2006; Hill et al., 2016). These alarming concerns have threatened the progress of UN sustainable development goal worldwide (Anderson, 2012). So, the key questions emerge, how do we respond? It is through by two key strategies, mitigation and adaptation (IPCC, 2014). Mitigation means reducing greenhouse gases from the atmosphere; Adaptation reduces vulnerability through social, economic and ecological systems (Anderson,

2012). However, both of them need more than technology they need political intervention, change attitudes and lifestyle and above engaged all citizens (Stevenson et al., 2017). That is where education comes into play a significant role. The need for environmental education is more important than ever, especially at university level. Because university students are the future policy makers, leaders, educators and will play to change the shift towards environmental movement to a positive direction. So, by changing their attitude towards environmental effect is most important than others.

Research shows that quality climate change education enhances understanding and motivates behavioral change. However and this is the gap in current research we know surprisingly little about how this actually happens. Does environmental education directly change preparedness, or does it first build awareness, which then drives preparedness? Limited research investigates these mechanisms, and even fewer studies examine this question in South Asia, where climate vulnerability is acute. Bangladesh, in particular, faces existential climate risks yet has limited research on how university education can build climate preparedness among students.

Research Objectives

This study aimed to examine how environmental education influences climate change preparedness among university students through the mediating role of environmental awareness. Specifically, the study seeks to assess the level of environmental education, environmental awareness, and climate change preparedness among university students, investigate the mediating role of environmental awareness in the relationship between environmental education and climate change preparedness, and examine differences in these three variables across demographic groups.

2. LITERATURE REVIEW

2.1 Environmental Education's Role in Higher Education Institutions

Increasing environmental degradation has led to the emergency of incorporating of environmental education into university curricula. In this regard, Krasny & DuBois (2019) explained that environmental education is the driving force that brings environmental awareness and behavioral change into the students. As Molthan-Hill et al. (2019) identified that climate change mitigation and adaptation itself as an urgent matter that we must prepare students to tackle the challenges of environmental education thus, continuing with this notion in mind, Tkachuck et al. (2018) defined universities as promising institutions best fit for raising the awareness amongst students about pressing environmental and social agendas.

But evidence shows universities need to take their role beyond classrooms. According to (Godwell & Nompe (2014), universities have to be in two alternate change vehicles: by reducing their own carbon emissions through green campus initiative collaborating with local communities. This is important because, as Choi et al. (2017) illustrated, not only do university climate change education programs convey knowledge, but they also immediately influence student behavior and practice effects which extend over

the lifetime of students and may impact generations to come. But what kind of environmental education really works? According to Cordero et al. (2020), Climate change education can motivate students to activism and engagement with stakeholders. However, Leal Filho et al. (2019) found another study a few years back indicates a clear pattern: universities focus on energy-efficient buildings rather than switching to renewable energy which needs to be applied, and this issue comes down between teaching and practice. As Filho (2010) pointed out years ago, climate change education cannot be confused or mixed up with the broader sustainability education; they are interconnected and mutually reinforcing but they take place in different institutional levels and need different approaches.

More critically, Akrofi et al. (2019) discovered something very unusual, that the participation of students in climate workshops and campaigns significantly improved knowledge while, membership in climate-focused student clubs had no significant impact. This directly contradicts the assumptions of organization membership. Furthermore, Burkholder et al. (2017) mentioned that climate literacy and sustainability factors have to be actively taught that mere exposure is not enough. Burkholder et al. (2017) emphasized that educational programs must be deliberately designed to increase climate literacy and empower students toward sustainability suggesting that passive exposure is less important. The implication is striking, suggesting that active engagement, experiential learning drives preparedness; passive membership does not make changes.

2.2 Climate change Awareness and Preparedness Among University Students

So, there is a basic question emerge here, if environmental education is the basement, then what about awareness? However, many developing countries that are most severely affected by climate change witness a growing level of environmental awareness (Guo et al., 2021). Ramsey et al. (1992) first addressed the modelling theory with environmental awareness, which established the core concept that environmental awareness, individual's understanding about their actions and the consciousness their actions impact the environment, is a necessary for solving any environmental problem. So, it's all about perceived understanding of action on environment. Recent research provides new evidence to back up this premise. Mkumbachi et al. (2020) was to reinstate that awareness is crucial for growing informed, creating responsible environmental citizens. But scholars have begun to question whether awareness actually ends in action. Omoogun et al. (2016) discovered an essential something, environmental education can result in increased awareness, but unless the attitudes about the quality of the environment are improved awareness does not transfer to respect for the environment. This is a crucial Fu et al. (2020) traced a distinction between knowledge about environmental problems and pro-environmental behavior. (Kollmuss & Agyeman (2002) and Steg & Vlek (2009) showed that climate knowledge behaving inconsistently across all ranges of age, education, awareness accessibility which seems to suggest that knowledge is not evenly distributed among different generations or populational levels.

This disparity in awareness also leads to a variation in readiness. As climate awareness defined by Yeung (1998) the ability of individuals to diagnose environmental processes and problems, evaluate threats to environmental quality and act with a commitment within their daily lives to sustain or improve the

environment. Climate awareness is one example of action competence involving cognitive engagement in climate change. More specifically, Lawrance et al. (2022) refers to climate awareness, which means the awareness of climate problems such as increasing temperature and sea level, extreme weather and global are warming. These definitions not only encourage knowledge, but competence and conviction. But this as the literature shows here is a vital gap, awareness does not mean preparedness itself. They took an example proposed by Wachholz et al. (2014) that students are increasingly aware of environmental disasters but few know what need to do about it. This is further developed by Safapour et al. (2021) despite the increased awareness there are unfortunately numerous universities and schools that still have a low level of disaster planning preparedness, response and mitigation strategies. Why is this occurred? Because as Patel et al. stated that, well-trained students with rescue skills and preparedness knowledge become valuable community and disaster management assets but without this training, awareness remains inactive. So, the message is clear, without being practical knowledge only awareness could not make them prepared that why institutional support must for gaining practical skills. Burgess et al. (1998) confirmed that this also, environmental knowledge does lead to greater environmental awareness, which does then lead to pro-environmental behavior but the bridge from awareness to behavior needs more than education. According to D'Andrea et al., (2023), man-made activities are the key drivers of environmental decline, so education on those effects should therefore be utilized not only for greater awareness but perhaps also with the aim to encourage responsibility.

2.3 The Integrated Relationship Between Environmental Education, Environmental Awareness, and Climate Change Preparedness

From diving into existing literatures, there is a strong link in environmental education with climate awareness and preparedness. Researchers point out that informed about climate change effects, exhibit control behaviors and lower environmental damages among individuals. Other scholars suggested an embedded route. As Filho (2011) and Cortese (2003) showed, universities have a very high responsibility in shaping a sustainable future through the inclusion of environmental education across disciplines as well as practical engagement experiences and fostering sustainability leadership. This argument is even reinforced by Dzimińska et al. (2020) claiming that higher education creates students' value systems connected to environmental responsibility making universities a major cultural bearer of change for sustainable development. The "Science Education for Responsible Citizenship" report of the European Commission advocates to provide scientific knowledge and understanding about climate education that will allow an active, responsible environmental engagement (Murzyn et al., 2025). Clayton & Myers (2015) outlined a more direct and interesting route that people will move to environment-friendly behavior if they are aware that their actions cause environmental damage badly.

However, empirical evidence supports this integrated pathway is limited and contestable. Education for sustainable development leads to economically secure, environmentally stable and socially just conditions more quickly than would otherwise occur (Sterling, 2001), but the process through which education brings about these changes is not defined. Dalelo (2011) and Waktola (2009), using several case studies conducted in Ethiopia, prove the crucial role environmental education plays in making students

environmentally aware and knowledgeable but they do not investigate if awareness generates preparedness.

Akrofi et al. (2019) established that students' attitudes and behaviors influence on their climate change awareness and knowledge levels, with active participation in climate course engagement, workshop involvement, environmentalist group membership, and climate information access. This indicates that strong preparedness is built from collaborative interaction, not isolated strategies can make it happen. Filho et al. (2022) mentioned students exhibited considerable heterogeneity in their engagement, but what drives that variation in behavior is not yet understood (Kollmuss & Agyeman, 2002). Most significantly Ofori et al. (2023) identified an additional major limitation that student attitude conducive to climate action does not always lead on its own to behavior, and this kind of targeted intervention requires an in-depth integrative approach focusing both on “climate knowledge” and “behavioral determinants” alongside practical and community-based education.

It's at that tension, the literature falls to pieces right here. McKeown & Hopkins (2010) mentioned that effective environmental education must develop critical thinking, “the ability to consider an issue from multiple viewpoints and develop a plan of action”. This cognitive ability, they argue, sets apart engaged climate education from mere information transmittal. If true then the immediate follow up question is: does this mean environmental education results in preparedness directly or it leads to awareness and then ultimately preparedness? Furthermore, institutional support matters after all. As Tkachuck et al. (2018) illustrated, university disaster preparedness courses must work with local officials in order to be effective to prepare universities and their communities for potential disasters. But relatively few universities have ensured these partnerships or required them.

This is the critical gap. The answer, supported by other research, is that environmental education matters, awareness matters and preparedness matters altogether. These variables are indeed correlated with each other. Yet no study has empirically tested whether environmental awareness mediates that is, explains the mechanism by which environmental education produces climate preparedness. This is especially true in the Bangladesh context, where students face acute climate vulnerability from cyclones, flooding, and sea-level rise, and where universities play a central role in building national adaptive capacity. Understanding this mediation pathway is not an academic exercise; it directly informs how universities structure curricula and institutional partnerships to build student preparedness.

H1

Environmental awareness mediates the relationship between environmental education and climate change preparedness.

3. Methodology

3.1 Participants and study design

We conducted a cross-sectional study in Noakhali Science and Technology University (NSTU), Bangladesh from June to August 2025. The study was consisting of eight academic departments students; Environmental Science and Disaster Management, Oceanography, Zoology, Economics, Education, Educational Administration DBA & Agriculture. Criteria for inclusion were, being enrolled an undergraduate or postgraduate student at the time of data collection; 18 years or older, and ability to read and understand the questionnaire. An online Google survey administered via email was sent to students who were invited to participate voluntarily.

Two stages sampling technique were used in this study. The first step was to utilize purposive sampling; we focused on departments that offered one or more environmental course(s) in a semester, this allowed to prioritize data most aligned to our research question (Moniruzzaman Sarker & AL-Muaalemi, 2022). Secondly, data was randomly collected from the participants to ensure unbiased selection and equal opportunities in taking part for all students (Zikmund et al., 2013). This process enabled us to recruit departments interested in the environment but did not introduce bias into selection of participants. The survey was completed by a total of 380 students. Sample size was calculated as per (Hair et al., 2017), recommended that data should collect at least 10 time greater than the study variable, so our minimal-required sample size were 300 participants. This sample of 380 exceeded this threshold, allowing for greater statistical power and less measurement error.

3.2 Instruments

3.2.1 Demographic

Participants reported their gender (male/female), year of study (1st, 2nd, 3rd, 4th, postgraduate), academic department, place of residence (family home, on-campus, off-campus), enrollment in environmental course (yes/no), and participation in climate-related education events (yes/no).

3.2.2 Environmental Education Scale (EES): Environmental education exposure was assessed using the Environmental Education Scale (EES) developed by (Kaplowitz & Levine, 2005). In the original scale there were 26 items, in this study we used 10 items which mostly relevant to the study objectives. The EES consists of 10 items measuring the extent to which students have been exposed to formal environmental education in their academic curriculum and co-curricular activities. Example items include; “My university courses have significantly increased my understanding of environmental issues”. Responses are recorded on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with a total composite score ranging from 10 to 50. Higher scores indicate greater exposure to environmental education.

3.2.3 Environmental Awareness Scale (EAS): Environmental awareness was measured using the New Ecological Paradigm (NEP) Scale developed by (Dunlap et al., 2000), which originally comprised 15 items measuring ecological worldview across five theoretical dimensions. In this study 10-item version used in this study assesses students' ecological worldview and understanding of environmental issues. All items were scored on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), with 5 items reverse-scored to correct directionality. The composite EAS score ranges from 10 to 50, with higher scores indicating stronger environmental awareness and pro-environmental values.

3.2.4 Climate Change Preparedness Scale (CCPS): Climate change preparedness was assessed using the Climate Change Preparedness Scale developed by (Van Valkengoed et al., 2021). This 10-item scale measures the extent to which students engage in behavior to prepare for and adapt to climate change impacts. Items include " I take steps to reduce my personal environmental impact to help address climate change", " I adjust my daily activities or routines in response to climate-related conditions or events." Responses are on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Higher scores represent greater climate change preparedness and adaptive capacity.

3.3 Statistical Analysis

In this study total analysis proceeded in logical steps by using IBM SPSS (version 25). Descriptive Statistics first, we computed descriptive statistics (frequencies and percentages) for all demographic variables and the main scales (mean, SD). We used Kolmogorov–Smirnov and Shapiro–Wilk tests, in addition to a visual examination of skewness and kurtosis as the assessment of sample normality for our three study measured scales EES, EAS and CCPS. Data were normally distributed and met normality assumptions since values were within ± 2.0 (George & Mallery, 2010). Then, reliability test was then calculated using Cronbach's alpha (Taber, 2018), with $\alpha \geq .70$ thresholds, indicates acceptable internal consistency. Reliability of the three scales were acceptable (EES $\alpha = .774$, EAS $\alpha = .739$, CCPS $\alpha = .788$).

For the parametric test, independent samples t-tests were conducted to test for differences in EES, EAS, and CCPS across gender, environmental course enrollment, and participation in a climate event. One-way ANOVA was performed to test differences across year of study, department and residence. Levene's test was conducted for homogeneity of variance assumptions and when these were not met, we reported "equal variances not assumed" results. When ANOVA revealed significant differences between the means ($p < .05$), Tukey post-hoc tests revealed group differences between specific pairs of comparisons.

Pearson correlation analysis was conducted to evaluate the relationships between EES and EAS and CCPS. This was important to meet the preconditions for mediation analysis. Lastly, we checked our mediation hypothesis with the PROCESS macro 4 (Hayes, 2018). In this analysis, three paths were included to determine if environmental awareness acts as a mediator in the direct (path c') EES-CCPS relation; through awareness (path $a \times b$), and the total effect (path c). We used unstandardized regression coefficients (β) with 95% confidence intervals to operate estimates, and bootstrapping estimated indirect effects using 5,000 resamples. The indirect effects were considered significant when the 95% confidence interval did not include zero. Statistical significance was set at $p < .05$ throughout.

4. Analysis and findings

4.1. Participants profile

Regarding gender, it comprised 160 male students (42.1%) and 220 female students (57.9%), revealing a females-dominated distribution. Out of 380 who completed the survey, the largest group were second-year students ($n = 92$, 24.2%), followed by third-year ($n = 91$, 23.9%), fourth-year ($n = 78$, 20.5%), first year ($n = 76$, 20.0%) and a few postgraduate students ($n = 43$; 11.3%). Participants were recruited from eight

academic disciplines, with Environmental Science and Disaster Management (n = 50, 13.2%) and Economics (n = 50, 13.2%) accounting for the greatest proportions, followed by Zoology (n = 48, 12.6%), DBA (n = 48, 12.6%), Education (n = 47, 12.4%), Agriculture (n = 47, 12.4%), Oceanography (n = 45, 11.8%) and Educational Administration (n = 45, 11.8%). Regarding residence of students the majority of them resided in family homes (n = 154, 40.5%) followed by on-campus accommodation (n = 136, 35.8%) and off-campus housing (n = 90, 23.7%). In terms of environmental education, the majority of participants (n = 218, 57.4%) had taken at least one formal environmental course during their coursework and 162 students (42.6%) reported having not taken such a class. Finally, in relation to participation in other climate educational events (e.g. seminars, workshops or awareness campaigns) 168 students (44.2%) who participated while 212 students (55.8%) did not participate (see Table 1).

4.2. Descriptive Statistics, Reliability, and Normality

Before analysis the parametric test, reliability and normality was checked to ensure that all the data is eligible for further analysis and the result showed a very satisfying result that all the data in a good manner and can perform the further analysis. Descriptive statistics revealed that the sample demonstrated moderate levels across all three constructs. The Environmental Education Scale of 32.94 (SD = 4.34), all falling within the moderate range on a 50-point composite scale.

Reliability analysis confirmed acceptable internal consistency for all three instruments, with Cronbach's alpha values of $\alpha.774$ for EES, $\alpha.739$ for EAS, and $\alpha.788$ for CCPS, all exceeding the minimum threshold of $\alpha.70$ recommended by (Taber, 2018). Beside the normality test was performed to ensure that data assumed the normality assumption. (EES) yielded a mean of 32.08 (SD = 4.26), the Environmental Awareness Scale (EAS) produced a mean of 31.51 (SD = 3.92), and the Climate Change Preparedness Scale (CCPS) returned a mean. Normality was assessed through the Kolmogorov-Smirnov and Shapiro-Wilk tests alongside skewness and kurtosis statistics. Although both formal tests yielded significant results ($p < .05$), this is expected with large samples ($N = 380$) where such tests are highly sensitive to minor distributional deviations (Ghasemi & Zahediasl, 2012). Skewness values for EES (.193), EAS (-.158), and CCPS (.178), and kurtosis values for EES (-.104), EAS (-.015), and CCPS (.031) were all well within the acceptable ± 2.0 range (George & Mallery, 2010), confirming approximate normality and supporting the use of parametric tests throughout the analysis.

Table 1
Sample's Description.

Characteristics	Absolute values (n)	Percentage values %
Sexual identity		
Male	160	42.1
Female	220	57.9
Total	380	100.0
Current study year		
1st year	76	20.0
2nd year	92	24.2
3rd year	91	23.9
4th year	78	20.5
Postgraduate	43	11.3
Total	380	100.0
Department of study		
Environmental Science & Disaster Management	50	13.2
Oceanography	45	11.8
Zoology	48	12.6
Economics	50	13.2
Education	47	12.4
Educational Administration	45	11.8
DBA	48	12.6
Agriculture	47	12.4
Total	380	100.0
Where do they live		
Family home	154	40.5
On campus	136	35.8
Off campus	90	23.7
Total	380	100.0
<i>Source: Author's compilation</i>		

Characteristics	Absolute values (n)	Percentage values %
Sexual identity		
Took any environmental courses in academic		
Yes	218	57.4
No	162	42.6
Total	380	100.0
Participated in any climate education events		
Yes	168	44.2
No	212	55.8
Total	380	100.0
<i>Source: Author's compilation</i>		

4.3. Group Differences in EES, EAS, and CCPS by participant's demographic profile

We performed independent samples t-tests to determine whether environmental education, awareness and preparedness differed across demographic groups. T-tests were used to test for gender, course enrollment and participation in climate events while ANOVA was used for year of study, department and residence. Results are shown in (Table 2).

Table 2

Differences in Environmental Education, Environmental Awareness, and Climate Change Preparedness by Demographic Characteristics (N = 380).

	EES			EAS			CCPS		
	Mean	Statistic	p	Mean	Statistic	p	Mean	Statistic	p
Gender:									
Male	31.99			31.83			33.21		
Female	32.06	-.150	<i>.881</i>	31.31	1.322	<i>.187</i>	32.81	0.892	<i>.373</i>
Enrolled in Environmental Course:									
Yes	33.21			33.02			35.24		
No	30.45	6.702	<i>.000*</i>	29.51	9.803	<i>.000*</i>	29.94	14.376	<i>.000*</i>
Participated in Climate Education Event:									
Yes	32.04			31.80			33.88		
No	32.02	0.042	<i>.967</i>	31.31	1.220	<i>.223</i>	32.27	3.577	<i>.000*</i>
Department of Study:									
Env. Science & Disaster Mgt.	32.56			31.76			33.30		
Oceanography	32.29			31.38			33.53		
Zoology	31.65			31.04			33.35		
Economics	32.64			31.78			32.44		
Education	31.83			31.04			32.77		
Educational Administration	31.76			31.80			32.67		
DBA	31.77			31.88			32.85		
Note: Independent sample t-test p value in <i>italic</i> ; ANOVA p value otherwise. * p < .05.									
Source: Author's compilation									

	EES			EAS			CCPS		
	Mean	Statistic	p	Mean	Statistic	p	Mean	Statistic	p
Gender:									
Agriculture	31.70	0.454	.867	31.51	0.364	.923	32.94	0.345	.933
Year of Study:									
1st Year	32.29			31.51			31.89		
2nd Year	32.21			30.34			31.28		
3rd Year	31.35			31.19			32.29		
4th Year	32.09			32.77			35.23		
Postgraduate	32.53	0.870	.482	32.56	5.385	.000*	35.91	17.503	.000*
Living Arrangement:									
Family Home	32.16			31.66			33.00		
On Campus	31.61			31.18			32.80		
Off Campus	32.46	1.219	.297	31.83	0.929	.396	33.21	0.235	.791
Note: Independent sample t-test p value in <i>italic</i> ; ANOVA p value otherwise. * p < .05.									
Source: Author's compilation									

There was no significant difference in EES between genders ($t = -.150$, $p = .881$), EAS ($t = 1.322$, $p = .187$), or CCPS ($t = .892$, $p = .373$). Male and female students exhibited the same level of environmental educational preparedness as well as environmental awareness. Levene's test indicated unequal variances for EAS ($F = 4.861$, $p = .028$) and CCPS ($F = 3.945$, $p = .048$), so equal variances not assumed results were reported for these variables; EES showed equal variances ($F = 3.029$, $p = .083$). In terms of enrollment in environmental courses, however, the results were significantly different across all three scales, students who had formally registered for environmental courses ($n = 218$) scored higher than non-enrolled students ($n = 162$), EES ($t = 6.702$, $p < .001$), EAS ($t = 9.803$, $p < .001$); and CCPS ($t = 14.376$, $p < .001$). Students enrolled in courses scored 2.76 points higher on education, 3.51 points higher on awareness, and 5.30 points higher on preparedness. This was the strongest and most consistent effect identified, suggesting that taking a formal coursework in the environment positively impacts all three constructs.

As for participation in climate events, the results were mixed. For environmental education, there was no significant difference ($t = .042$, $p = .967$) and environmental awareness ($t = 1.220$, $p = .223$). However, the participants scored considerably greater in preparedness than non-participants ($t = 3.577$, $p < .001$). This behavior indicates a capacity of experiential climate engagement to enhance preparedness, or education outside of formal learning or education on the environment.

A one-way ANOVA examined differences across year groups (1st year through postgraduate). Levene's test confirmed homogeneity of variances for all three scales ($p > .05$). Year of study produced mixed results. Environmental education exposure did not differ significantly across years ($F(4, 375) = .870, p = .482$), indicating that exposure does not accumulate systematically with academic progression. However, both environmental awareness ($F(4, 375) = 5.385, p < .001$) and climate change preparedness ($F(4, 375) = 17.503, p < .001$) showed significant year-of-study effects. Tukey post-hoc analysis revealed that 4th year ($M = 32.77$) and postgraduate students ($M = 32.56$) scored significantly higher on awareness than 2nd year students ($M = 30.34, p < .001$ and $p = .014$, respectively). For preparedness, 4th year ($M = 35.23$) and postgraduate students ($M = 35.91$) scored significantly higher than 1st year ($M = 31.89, p < .001$), 2nd year ($M = 31.28, p < .001$), and 3rd year students ($M = 32.29, p < .001$). However, there were no significant differences across all three variables in academic departments and residential area of the participants.

4.4 Mediation Analysis: The Mediating Role of Environmental Awareness

In this study we used PROCESS macro (Model 4) to examine whether environmental awareness (EAS) functions as a mediating variable in the relationship between environmental education (EES) and climate change preparedness (CCPS). PROCESS Model 4 is a single-mediator, path-analytic framework that estimates (a) the indirect effect of the independent variable on the outcome via the proposed mediator, (b) the direct effect of the independent variable on the outcome after controlling for the mediator, and (c) the total effect of the independent variable. Bootstrapping with 5,000 resamples was used to generate bias-corrected 95% confidence intervals (CIs) for the indirect effect, consistent with contemporary best practices for mediation testing (Preacher & Hayes, 2008). This analysis tested whether, Environmental awareness significantly mediates the relationship between environmental education and climate change preparedness. Mediation analysis showed that environmental education influenced climate change preparedness both directly and indirectly through the mediating effect of environmental awareness which support the hypothesis 1 (Figure:1, Table:3).

Table 3 presents the path coefficients obtained from the PROCESS Model 4 mediation analysis. Notably, all paths reached statistical significance at $p < .001$, and the unstandardized regression coefficients (β), together with their standard errors, t -values, and 95% confidence intervals, are reported in full.

As shown in Table 3, environmental education was found to significantly predict environmental awareness ($\beta = .431, p < .001$). In other words, students who are more engaged to formal environmental education represented higher levels of environmental awareness. The model summary for this relationship is provided in Table 4, shows environmental education explains a substantial proportion of variance in environmental awareness ($R^2 = .219, F(1, 378) = 105.893, p < .001$), indicating a significant large effect size. Furthermore, environmental awareness, on the other hand, significantly predicted climate change preparedness ($\beta = .589, p < .001$), even after controlling for environmental education. This suggests that students with greater awareness are more likely to be better prepared for climate-related challenges. At the same time, the direct effect of environmental education on climate change preparedness remained statistically significant ($\beta = .246, p < .001$), even after accounting for the mediating role of environmental

awareness. As indicated in Table 4, the full model—including both environmental education (EES) and environmental awareness (EAS)—explained 43.2% of the variance in climate change preparedness ($R^2 = .432$, $F(2, 377) = 143.620$, $p < .001$), which can be considered a large effect. By comparison, before introducing the mediator, environmental education alone explained 22.5% of the variance in climate change preparedness ($R^2 = .225$, $F(1, 378) = 109.916$, $p < .001$). The total effect of environmental education on climate change preparedness was also positive and statistically significant ($\beta = .500$, $SE = .048$, $t(378) = 10.484$, $p < .001$). Importantly in (Table 3, the indirect effect of environmental education on climate change preparedness through environmental awareness was .254 (Boot SE = .033, 95% Boot CI [.192, .322]). Since the confidence interval does not include zero, this indirect effect is statistically significant. This finding confirms that environmental awareness plays a meaningful mediating role in the relationship between environmental education and climate change preparedness. Notably, the direct effect ($\beta = .246$) decreased compared to the total effect ($\beta = .500$) after including the mediator in the model. This reduction, alongside the continued significance of the direct path, indicates partial mediation. In practical terms, this means that environmental education influences students' preparedness for climate change both directly and indirectly, by fostering greater environmental awareness.

Table 3
Path Coefficients for the Mediation Model (PROCESS Model 4)

	β	SE	t	p	LLCI	ULCI
EAS (Mediator) – Path a						
EES → EAS (Path a)	.431	.042	10.290	< .001	.349	.514
CCPS (Dependent Variable) – Paths b and c'						
EAS → CCPS (Path b)	.589	.050	11.731	< .001	.490	.687
EES → CCPS (Path c', Direct)	.246	.046	5.324	< .001	.155	.337
Total Effect – Path c						
EES → CCPS (Path c, Total)	.500	.048	10.484	< .001	.407	.594
Indirect Effect via EAS						
EES → EAS → CCPS	.254	.033	—	—	.192	.322
<i>Source: Author's compilation</i>						

Table 4
Model Summary Statistics for the Mediation Analysis

Outcome Variable	R	R ²	F	p
EAS – Path a model (Mediator)	.468	.219	105.893	< .001
CCPS – Full model (Paths b & c')	.658	.432	143.620	< .001
CCPS – Total effect (Path c)	.475	.225	109.916	< .001
Note. N = 380. R ² values indicate the proportion of variance explained in each outcome variable.				
<i>Source: Author's compilation</i>				

5. Discussion

This study examined the relationship between environmental education, environmental awareness, and climate change preparedness among 380 university students at NSTU, Bangladesh. The primary finding confirms our hypothesis: environmental awareness significantly mediates the effect of environmental education on climate change preparedness. Beyond this central finding, demographic analysis reveals important patterns about who benefits from environmental education and how awareness develops.

In this study, no significant difference in gender role was found on any measure EES ($p = .881$), EAS ($p = .187$), and CCPS ($p = .373$), which implies that both male and female students showed similar level of environmental engagement. This was also found to Ribeiro et al. (2020) in a similar way, found no difference between genders with the younger university cohorts in their study. In fact, this gender equality also plays to the advantage of environmental process, that it views environmental consciousness and action as a human-based endeavor rather than gender lens. Environmental awareness should possess in both men and women at the same level and this study confirm that both male and female have the similar level of concert at this point. However, this study also contradicts with some early studies, which found that, environmental awareness possesses greater in female students than male and female students have a more caring behavior than male students (Ningrum & Herdiansyah, 2018; Vicente-Molina et al., 2013). Again, Demaidi & Al-Sahili (2021) found another interesting result, male had much more aware about climate change. Mkumbachi et al. (2020) complexified this finding by showing that female engineering students in societies were significantly more self-aware than those outside these groups. When looking across contexts, the results are more mixed and suggest that gender effects are not only due to gender role but rather institutional culture and disciplinary exposure where those were better in some settings than others, which may explain why no divide occurred among our Bangladeshi sample. Notably when institution offer same education and ensure participation beyond the gender role the possibility of shaping behavior more frequent. However, in this study, no significant effects of any academic departments have found (all $p > .05$) despite studies proving that science related departments tend to have more environmental awareness than others (Ofori et al., 2023). Haq & Ahmed (2020) and Beck et al. (2013) reported that the climate knowledge of students in science and agriculture faculties is much greater than that of engineering, business or education. However, this finding indicates that climate related content

may be more evenly distributed in faculties across disciplines as curriculum integration rather than disciplinary segregation an important change in the regional higher education practices. Conversely, formal enrolment in environmental courses found significant in this study all three measures with strong differences EES: $t = 6.702, p < .001$; EAS: $t = 9.803, p < .001$; CCPS: $t = 14.376, p < .001$). It suggested that students enrolled in the course had scores of 3.51 higher average score on awareness and 5.30 points higher on preparedness differences that are educationally substantial. This is exactly stated by Ofori et al. (2023), students who took formal climate change education reported significantly more engagement in preparedness behaviors. Formal coursework seems to enhance understanding of climate issues and achieve authentic engagement with phenomena in the world indicating that curricular design is more important than individual difference. Climate event participation had a statistically significant selective effect regarding preparedness ($t = 3.577, p < .001$) but no significance was found in education and awareness. Like the studies above, studies found that experiential engagement activates preparedness through mechanisms other than formal learning—perhaps active engagement, social influence, or skill-building rather than just knowledge. This discriminating impact is telling, it shows that there are several routes to preparedness and so universities should not presume one sort of intervention (formal or experiential) equally serves all results. Year of study significantly differentiated awareness ($F(4, 375) = 5.385, p < .001$) and preparedness ($F(4, 375) = 17.503, p < .001$) but not education exposure ($F = .870, p = .482$). Four year and postgraduate students scored significantly higher than junior students for both awareness and preparedness yet had equivalent education exposure across years. This is because in many universities they introduce environmental courses in the final academic year, that why students get the opportunity to gain a holistic understanding at the last. Furthermore, Akrofi et al. (2019) attributed similar patterns to cognitive development and identity formation, as students' progress, they develop sharper critical thinking, anticipate future roles, and accumulate lived experience with environmental consequences. And because students in Bangladesh experience flooding and cyclones more frequent, this accumulated lived experience likely compounds with formal instruction to deepen genuine preparedness as students mature suggesting that coursework must be anchored to students' real-world environmental realities, especially for first- and second-year students who may not yet grasp climate urgency.

On the other hand, mediation analysis represents the main theoretical contribution of this study. There was significant mediation of the education-preparedness relationship by environmental awareness which support our only hypothesis: path a (education $\rightarrow$ awareness: $\beta = .431, p < .001$) and path b (awareness $\rightarrow$ preparedness: $\beta = .589, p < .001$), the significant indirect effect was $\beta = .254$ (95% CI [.192, .322]). These two-stage mechanism is consistent with value-attitude-behavior theory where education shifts underneath values and attitudes that motivate behavior change (Van Valkengoed et al., 2021; Weber & Stern, 2011). Several studies have identified that, people who are more environmentally aware are much more likely to engage in sustainable behavior (Kikuchi-Uehara et al., 2016; Sekhokoane et al., 2017; Zhang & Zhou, 2016). According to Carmi (2013), awareness is itself the behavior factor of caring for the environment, and it emerges from education. When combined, these discoveries show awareness to be an intermediary between the psychological education educates but awareness mobilizes that knowledge into active force. An important takeaway was that awareness and preparedness naturally evolve across the academic years while educational exposure does not. According to (Ayanlade & Jegede, 2016), awareness develops over

the years through life experience, open discussions with peers, and experience of environmental consequences. In Bangladesh the context of this research, students experience climate impacts directly including floods, cyclones and seasonal disruption implicitly creating backlashes as people prepare more formal instruction. This is a signal that coursework alone will not suffice, and environmental educators are going to have to work extra with academic content particularly for those juniors who are gaining their first taste of climate shocks. The mediation model explained 43.2% of variance in preparedness ($R^2 = .432$), indicating that while education and awareness are powerful, additional factors risk perception, self-efficacy, socioeconomic resources, institutional support also shape preparedness. The strong mediation effect across all demographic subgroups (gender, department, residence) demonstrates generalizability, suggesting universities can implement similar curriculum approaches with confidence that benefits will reach diverse student populations equitably. This study thus establishes not merely that environmental education matters, but precisely how it matters: through building awareness that motivates and enables taking climate action firsthand a mechanism that illuminates pathways for more effective future policy and practice.

Implications for Higher Education and Climate Action Policy

Realization of these findings have important implications for higher education administrators and stakeholders. To begin with, environmental education explicitly improves awareness and preparedness: in enrolled students scored 3.51 points higher on awareness and 5.30 points higher on preparedness than non-enrolled peers a gap large enough to justify continued investment in curriculum development. Yet since exposure does not accumulate across academic years, institutions would benefit from embedding environmental content across all four years through a spiral curriculum, rather than confining it to optional courses. Second, the mediation pathway (environmental education leads to awareness which drives preparedness) suggests a two-pronged approach. Universities should simultaneously build technical environmental knowledge (the direct pathway) and cultivate ecological values through reflection, case studies, and community engagement (the mediation pathway). Third, climate-related experiences and practice led to improvements in preparedness scores without having a negative impact on awareness or education scores, demonstrating that learning in the classroom and community engagement function through different mechanisms a complementary approach. It is thus imperative that universities need to do their bit to promote engagement in climate workshops and sustainability initiatives on the persist of coursework. Lastly, considering the predictability of cyclones, flooding and sea-level rise in Bangladesh these results highlight the importance of higher education as a lever for national climate resilience that leads environmental education in universities to be an imperative rather than just an additional option or enhancement.

Conclusion

This research explains that environmental education directly influences the climate change preparedness as well as indirectly when mediated by environmental awareness. Therefore, environmental awareness is one of the significant enabling pathways by which formalized education translates to individuals engaging in concrete protective behaviors. The effects of the nature experiences supporting nature education for a

wide range of demographics, such as gender, discipline and residency status appear to generalize well. This reinforces the need for environmental content to be integrated at all years of study (relative to both cumulative awareness and preparedness) because there are year-of-study effects on awareness and preparedness, but not education exposure. These kinds of findings strengthen the basis for investment in environmental education at universities of South Asia, and highlight that university education has a need to be a more central focus given the increasing vulnerability to climate change throughout Bangladesh.

Declarations

Declaration of interest

The authors declare that there are no potential conflicts of interest.

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Declaration of generative AI-assisted technologies in the writing process

Generative AI tools were used for limited language editing support during manuscript preparation, including assistance with grammar, sentence structure, and clarity of expression. All substantive aspects of the manuscript, including the research design, analysis, interpretation, and final content, were developed and critically reviewed by the authors, who take full responsibility for the accuracy and integrity of the work.

Ethics approval and consent to participate

This study received ethical approval from the Research and Ethics Committee, Department of Educational Administration, Noakhali Science and Technology University, Bangladesh (Approval No. NSTU/EA/2025/749; approved on 08 June 2025). All procedures involving human participants were conducted in accordance with the ethical standards of the approving committee, the institutional ethical guidelines of Noakhali Science and Technology University, and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to data collection, and participation was voluntary.

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Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Figures

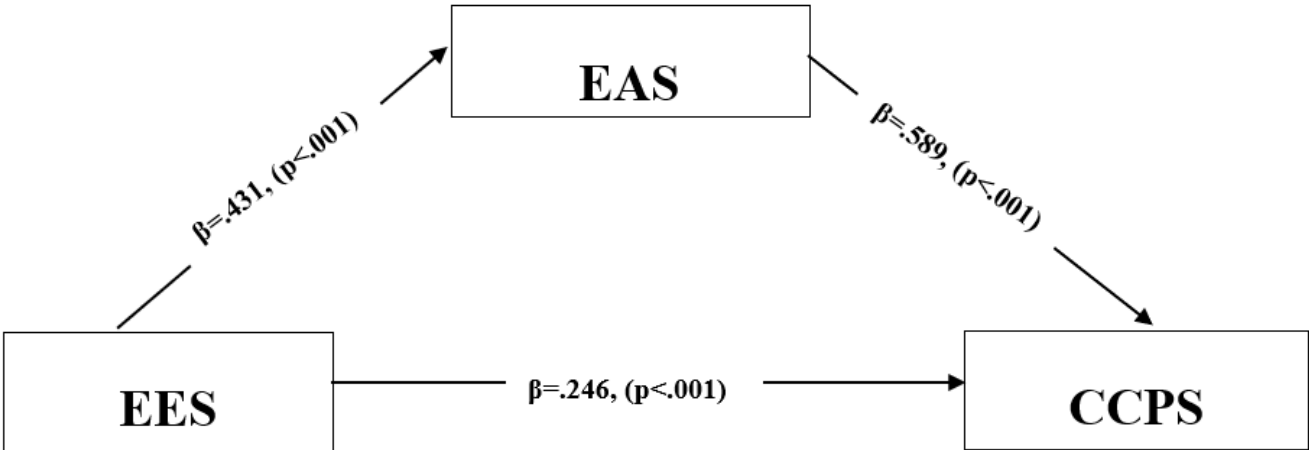


Figure 1

Structural mediation model using PROCESS macro (model 4) with path coefficients (β) and p values.

Source: Author's compilation