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CLIMATE CHANGE PERCEPTION, ACTION, AND HOPE AMONG HIGH SCHOOL STUDENTS: INSIGHTS FOR SCIENCE EDUCATION

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ABSTRACT

Current climate data shows that human-driven climate change is now affecting both nature and people irreversibly. Several studies have explored the perception, actions, and hopes of individuals regarding climate change, but few have analyzed their relationship. This study aimed to analyze students' perceptions, actions, and hopes, examine the structural relationships among these variables, and determine the mediating role of hope. A quantitative survey was conducted to statistically analyze students' perceptions, actions, and hopes. Results reveal strong agreement among students about the reality and anthropogenic causes of climate change. In terms of actions, students have relatively more participatory actions than leadership actions towards the environment. When it comes to hope, students generally believe in their own ability to act, but there are a few who exhibit hopelessness due to the complexity of climate change. Structural equation modeling reveals a positive relationship between perception and hope (r = 0.62), indicating that awareness promotes optimism about solutions. Moreover, mediation and path estimates revealed the mediating role of hope, suggesting that perception influences action through hope. These findings emphasize the need for climate change education to bridge the attitude-behavior gap by fostering a sense of hope and positive instruction to increase students' mitigative actions.

Keywords: action; climate change; climate change education; hope; perception

INTRODUCTION

The Intergovernmental Panel for Climate Change (IPCC) has recently released its Sixth Assessment Report, which provides current knowledge on the causes, widespread impacts and risks associated with climate change. The report and studies have shown that human activities are contributing to global warming through the emission of greenhouse gases (Calvin et al., 2023; Alakbarov & Hajiyeva, 2025; Zhou et al., 2025). Human-caused climate change is already having an impact on weather and climatic exteremes in every part of the world, which affects both nature and people (Calvin et al., 2023). Climate Change has caused damage and irreversible losses in terrestrial, freshwater, cryospheric, and coastal and open ocean systems, specifically loss of species driven by heat extremes (Lincoln et al., 2021; Liu et al., 2021; Calvin et al., 2023; Geng et al., 2023; Johnson et al., 2023; Wudu et al., 2023; Bhowmik et al., 2024; Wang, 2024; Yao et al., 2024; Nimma et al., 2025). In relation to impacts on people, climate change has affected and reduced food security due to the warming of ocean and acidification, which affected production of food from fisheries and shellfish aquaculture (Duchenne-Moutien & Neetoo, 2021; Elver & Oral, 2021; Mirón et al., 2023). Climate change has also affected water security due to a combination of

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climatic and non-climatic drivers. Interestingly, climate change has caused adverse effects on human health as urban infrastructures have been compromised by extreme events, which affected the well-being of individuals (Gulzar et al., 2021; Rocque et al., 2025).

Climate change education (CCE) primarily aims to equip learners with the knowledge, skills, and attitudes needed to understand and address the complexities of climate change (CC). CCE requires students to acquire new knowledge and skills, and make significant behavioral changes to handle the risks associated with CC and reduce our vulnerabilities to these risks by fostering adaptive capacity and resilient societies (Mochizuki & Bryan, 2015). Educational institutions play a crucial role in achieving goals that transform students and address socio-environmental challenges. Schools equip youth in the form of knowledge, dispositions, and competencies to create a foundation for addressing current social and ecological challenges (White et al., 2023). However, achieving the goals of CCE requires both immediate and long-term responses to CC, including large-scale public awareness, formal educational initiatives, non-formal education, and multi-pronged educational approaches (Mochizuki & Bryan, 2015). Currently, efforts in climate change education have not met the urgent demand, despite the recognition it has received at the international policy level (Molthan-Hill et al., 2019). Current curricular constraints, such as the secondary science curricula's lack of room for science teachers to easily incorporate the topic into their instruction (Jones & Davison, 2021; Monroe et al., 2013). Another problem stems from the fact that educators' professional accreditation, evaluation, research, and development over the recent decade has remained focused on other matters (Reid, 2019).

Students have the right to be informed and involved in matters that will affect their lives since they will have to deal with the consequences of a future warmer environment. Students can contribute their voices to the public conversation around climate change and potentially influence responses by becoming involved. Their lifestyle decisions and actions can significantly impact greenhouse gas emissions reduction (Pickering et al., 2020). In the future, these students will play a crucial role in shaping decisions for a low-carbon future, addressing the environmental and societal consequences of climate change (Kuthe et al., 2019). Researchers argue that students are more likely to take climate action and make informed decisions once they are more educated about the causes of climate change and aware of potential strategies for action, which could increase their self-efficacy and agency (Baldwin et al., 2023). In contrast, current findings indicate that students struggle with the scientific concepts about climate change and often misinterpret information about climate change and environmental problems (Wildbichler et al., 2025). According to the literature, students confused global warming with ozone layer depletion (Kurup et al., 2021). Furthermore, students have a limited understanding of the human activities that contribute to climate change compared to those that do not directly impact it.

Although most people agree that climate change is real and that the world needs to act now (UNDP, 2024), individuals may still hold varying beliefs about the extent to which humans contribute to climate change and the consequences it will have. Climate change perception has been defined and distinguished as a tripartite framework that includes three components: (1) belief about the reality of CC, (2) causes of CC, and (3) consequences of CC (van Valkengoed et al., 2021). In addition, spatio-temporal consequences are another important dimension that defines perception. These perceptions of climate change are significant in understanding whether individuals take action to mitigate and adapt to climate change and support climate policies (Brügger et al., 2015). Climate change perceptions of people have been investigated by many studies already (Korkmaz, 2018; Bollettino et al., 2020; Jamshidi et al., n.d.; van Baal et al., 2023). Specifically, high school students still hold misconceptions about basic causes and consequences of climate change (Azeiteiro et al., 2018).

Knowledge is a crucial factor in promoting pro-environmental behavior; however, relying solely on scientific knowledge is insufficient to encourage individuals to take climate action. The relationship between climate science knowledge and willingness to take climate actions is not significant, with a negative relationship observed with the sense of personal responsibility for climate change (Kang & Tolppanen, 2024). In addition to knowledge, various factors influence individuals' willingness to engage in climate action, including values (Bouman et al., 2021), concerns (van der Linden, 2017), and responsibility (Jakučionytė-Skodienė & Liobikienė, 2021). Consequently, environmental behavior differs from environmental action, as the latter emphasizes changes at the societal level rather than the individual level (Alisat & Riemer, 2015). Since environmental problems are deeply ingrained in society and our way of li-

ving, it is necessary to address these issues at both the societal and individual levels (Mensah, 2019). Environmental action has been categorized into four sub-types, which include environmental activism, non-activist behaviors in the public sphere, private sphere environmentalism, and other environmentally significant behaviors (Stern, 2000). However, individuals, including teachers, tend to take low-impact mitigative actions, which could be due to various barriers, such as a lack of knowledge about consequences and potential solutions, attitudes towards the environment, social acceptance of behavior, values, and situational factors (Tolppanen et al., 2021). Moreover, there remains a scarcity of research investigating climate actions among individuals.

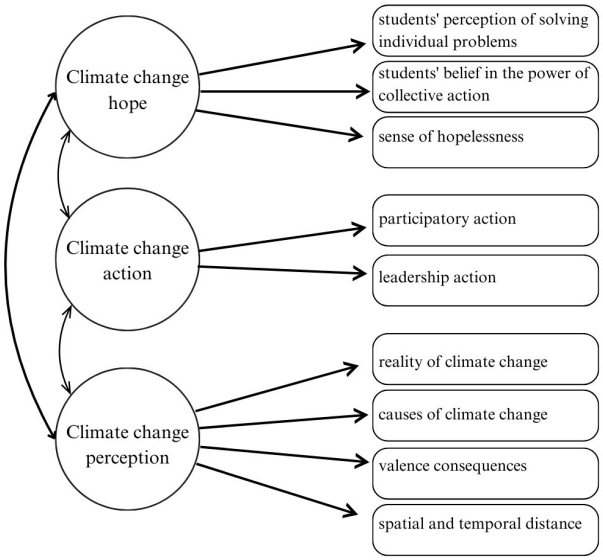

Figure 1. The Relationship of Climate Change Hope, Action, and Perception and Their Respective Components

The approach of most communicators, as well as teachers, to motivate actions that would allow individuals to avoid the damages of climate change includes highlighting the negative impacts of climate change on economies, human health, and communities. The intention is to elicit concern and mitigative actions. However, one of the issues facing the field of climate change communication, including education, is whether it is more successful to inspire the public with messages of hope and optimism or to scare them into pro-environmental concerns and behavior with information meant to arouse fear, or fear appeals (Ettinger et al., 2021). Researchers warn that fear appeals may trigger counterproductive responses, such as avoidance, denial, and reactance, when solutions are undesirable, unknown, or inaccessible (Marlon et al., 2019). Instruction and communication that are framed to elicit hope and positive emotions can enable individuals to act more effectively and collaboratively, as hope serves to motivate effort, goal achievement, and adaptive responses (Fritze et al., 2008; Marlon et al., 2019). A theory of hope proposes that it comprises three components: goals, pathway thinking, and agency (the drive to utilize these pathways) (Snyder et al., 2001; Ojala, 2012). Hope has been described as an individual's belief in the ability to pursue goals (Li & Monroe, 2018). Hope, as described by Snyder, involves staying motivated to achieve a future goal by anticipating it and actively devising different strategies to reach it (Ojala, 2023). Hope is a significant factor in engaging students in environmental action and enhancing their understanding of climate change (Liu et al., 2022).

Climate change hope is a crucial factor in driving climate action. Hope is composed of cognitive and emotional components that contemplate the future in a positive and agentic way, and therefore, it is an important motivator for climate action (Weber & Constantino, 2023). People who feel more hopeful about the Earth's climate are more likely to report engaging in pro-environmental behaviors (Maartensson & Loi, 2022). Evidence further suggests that hope is relevant in fostering behavioral mechanisms, specifically pro-environmental behaviors (Geiger et al., 2019). Changes in pathway thinking related to discussing climate change served as a mediator for the intervention's impact on the in-

crease in self-reported initiation of conversations about climate change. In terms of perceptions of climate change and climate action, a study has shown that as more people believe in the reality of climate change, they are more likely to engage in environmental action (Visschers, 2018). To increase concern about climate change, it is essential to consider individuals' perceptions of climate change. Moreover, a study found that a greater belief in the reality of climate change is positively correlated with pro-environmental action and future intentions to undertake such action (Stahlmann-Brown et al., 2025). Additionally, individuals who perceive a higher climate change risk tend to report performing more pro-environmental behaviors (Maartensson & Loi, 2022). However, the relationship between perception and action is rather weak (Masud et al., 2015; Bradley et al., 2020). Hope, as well, is interrelated with perceptions towards climate change. Perceptions of climate change risks, combined with positive emotions, can influence hope (Castellini et al., 2024). The perception of climate change risk, awareness of extreme weather, sea level rise, biodiversity loss, and the impacts on socioeconomic systems and human health are all improved by climate change optimism. Knowledge of the impacts of climate change was identified as one of the significant predictors.

Despite these insights, several important gaps remain in the literature. First, the nature of hope and its influence on climate action requires further clarification. While studies among adolescents suggest that hope may drive willingness to act, other studies, particularly among adults, indicate that hope can also function as an emotional coping mechanism that may reduce urgency to act (Armstrong & Krasny, 2020). This distinction between constructive hope, which motivates action, and wishful thinking, which may lead to complacency, remains underexplored, especially in youth populations (Krafft et al., 2020). Second, climate emotions are multifaceted and temporally variable, and research has not fully unpacked how positive emotions like hope interact with or counterbalance negative emotions such as fear, anxiety, or despair. As noted by Kovács et al. (2024), many climate emotions are transient, and the temporality and stability of hope as a motivating force remain unclear. More work is needed to understand how hope interacts with the broader emotional landscape surrounding climate change and whether it leads to sustained behavioral change over time. Finally, different components of climate change, including its causes, consequences, and solutions, may evoke distinct emotional and behavioral responses; yet, little is known about how these varied perceptions influence hope and action (Smith & Leiserowitz, 2014). This highlights the need for nuanced, context-specific studies that examine the interplay between cognition, emotion, and behavior in climate change engagement.

This study aimed to (1) describe the perceptions, actions, and hopes of high school students with respect to climate change, (2) examine the structural relationships among climate change perception, climate action, and hope among high school students, and (3) determine the mediating role of hope between the relationship of perception and action.

As this study provides valuable insights into the perceptions, actions, and hopes of high school students concerning climate change, certain limitations must be acknowledged. The use of a survey design restricts the capacity to infer causal relationships among the variables of interest. Although structural equation modelling was employed to assess the interrelationships and potential mediating effects, the data represent a single point in time, thereby limiting conclusions about the directionality of these associations. The sample's geographic and institutional scope presents a constraint to generalizability. Although efforts were made to include diverse participants in terms of grade level, gender identity, and academic strands, the findings may not fully represent the views and experiences of students from public schools, rural areas, or different socio-economic backgrounds across the Philippines. Additionally, while purposive sampling facilitated a focused exploration of a specific population, it inherently limits the randomness of participant selection. This may have inadvertently excluded students with differing perspectives or varying levels of engagement with climate change, which could impact the range and depth of the findings. Nonetheless, these limitations do not diminish the value of the study's contributions; rather, they suggest important directions for future research. Longitudinal designs, more diverse samples, and refined conceptualizations of hope and climate emotion could offer a more comprehensive understanding of youth climate engagement in future investigations.

Focusing on the cognitive and emotional responses of high school students to climate change, this study aligns with and supports United Nations Sustainable Development Goals (SDGs), including SDG 13 (Climate Action), SDG 4 (Quality Education), and SDG 3 (Good Health and Well-being). Understanding how

hope influences climate action can inform the development of educational and policy strategies that empower students to engage in sustainable behaviors. Hope-oriented climate change education is crucial for enabling transformative learning in the face of climate crises (Finnegan & d'Abreu, 2024). This research not only contributes to academic knowledge but also provides practical pathways for achieving long-term sustainability and resilience.

METHODS

A quantitative survey was conducted to statistically describe and determine the relationships of perceptions, actions, and hopes of high school students regarding climate change. Survey research is described as the gathering of information from a sample of individuals through their responses to a number of questions (Ponto, 2015). It is a systematic and efficient method of collecting data from a broad spectrum of individuals and educational settings. Data from surveys allows for the monitoring and analysis of important trends in society, specifically testing theoretical understanding of social processes.

The participants of this study consist of three hundred twenty-four (324) high school students from a private school from Malabon and Caloocan, Philippines. The participants consists of 50.9% females, 44% males, and 4.93% nonbinary. In terms of grade level, most participants are senior high school students (70.9%), and the rest are junior high school students (29.0%). The age of the respondents ranges from 12 to 18 years old, with 21% being 12 to 15 years old (junior high school students) and 78% being 16 to 18 years old (senior high school students). A purposive sampling method was employed to ensure representation across different year levels and academic programs. An online survey was conducted among all participants to gather quantitative data on their perceptions, actions, and hopes regarding climate change. All participants were provided with informed consent prior to their participation, and the study adhered to ethical research standards to ensure confidentiality and voluntary participation.

This study utilized the Climate Change Perception Scale developed by van Valkengoed and Perlaviciute (2021). The scale consists of 14 items distributed across five factors: perceptions of reality, causes, valence of consequences, spatial distance, and temporal distance. This instrument is designed to comprehensively measure participants' perceptions of climate change. The reliabilities of the subscales measuring each type of climate change perception were excellent, as they all exceeded 0.80.

To measure environmental actions, this study used the Environmental Action Scale by Alisat and Riemer (2015). The scale comprises 18 items divided into two sub-factors: participatory actions, which focus on collective efforts, and leadership actions, which emphasize taking initiative. This tool provides a comprehensive assessment of individual environmental behaviors. Coefficient alpha for the EAS scale was high, at 0.92.

To assess hope in the context of climate change, this study used the Climate Change Hope Scale by Li and Monroe (2018). The scale includes 11 items divided into three sub-factors: (a) collective-sphere willpower and waypower, (b) personal-sphere willpower and waypower, and (c) lack of willpower and waypower. This tool provided a comprehensive measure of students' hope related to climate change. The reliability coefficients of the scale are between 0.681 and 0.797 for each of the three dimensions.

The quantitative data were analyzed using descriptive statistics, including the calculation of means and standard deviations. These statistics help to measure the perceptions, actions, and hopes of high school students regarding climate change. Box plots were used to visualize this data. Inferential statistics, such as structural equation modeling, determined the relationships between perception, action, and hope, as well as the mediating role of hope. Jamovi version 2.4.14 was used to perform all analyses.

RESULTS AND DISCUSSION

The survey results provide insightful data on high school students' perceptions of climate change, revealing distinct trends in their beliefs and awareness (Figure 2). The highest mean score corresponds to item 1 (M = 5.673), which asks about students' beliefs on climate change, suggesting a strong agreement among respondents affirming the reality of climate change. The relatively low standard deviation (SD = 0.871) and variance (Var = 0.760) indicate a high level of agreement among students on this issue. A similar study that determined the climate change perception of senior high school students in Indonesia found that the majority of the students are aware of the reality of climate change and understand that climate change is driven by humans, and the impact of climate change has also been felt now and will worsen in the future (Kundariati et al., 2024). Despite the few climate denial reports in

other countries, this study further strengthens the strong belief of students in the reality of climate change in the Philippines.

Conversely, the lowest mean score is observed for a question if respondents do not believe that climate change is real (M = 1.386). The relatively lower variance (Var = 0.677) and standard deviation (SD = 0.823) further indicate a consensus among respondents in rejecting climate change denial. Another item with a low mean is about whether climate change is not occurring, indicating that most students strongly disagreed that climate change is not occurring, further reinforcing the prevailing acknowledgment of climate change.

Items related to activities of humans as a major cause of climate change, such as items 4 and 5, also received high agreement, as evidenced by their high means (M = 5.444 and 5.343, respectively). Most people also believe that human actions, such as deforestation, river dredging, sand extraction, industrial growth, and automobile carbon emissions, are to blame for climate change (Haq & Ahmed, 2020). Several factors may explain the variation in teachers' and students' understanding of climate change, including socio-demographics, experience with climate disasters, climate change-related education, and involvement in environmental activities (Ahmed et al., 2021).

Examining students' views on the consequences of climate change, item 9 indicated strong agreement on the statement that the consequences of climate change will be very serious (M=5.552). Other related statements, such as items 7 and 8, also show high agreement, confirming students' recognition of the serious negative effects of climate change (M = 5.349 and 5.426). Interestingly, items 13 and 14 received lower mean scores and relatively spread around the mean, indicating greater uncertainty or divided opinions on whether climate change impacts will only be experienced in the far future (M = 3.605 and 3.194, SD = 1.503 and 1.582). Previous studies have similarly pointed out that climate change, primarily caused by anthropogenic activities, can result in major consequences for society and the environment, such as heavy rainfall, drought, and storms (Trenberth, 2018). However, data also indicate that while students largely agree that climate change is real and serious, there is less consensus regarding the immediacy of its consequences. In contrast to this belief, the Intergovernmental Panel on Climate Change in its 6th Assessment report highlighted that continued greenhouse gas emissions will lead to increasing global warming, with the best estimate of reaching 1.5 °C in the near term, and every increment of global warming will intensify multiple and concurrent hazards (Calvin et al., 2023). This suggests that although students believe climate change will have serious consequences, they may have uncertainty about whether these consequences will be felt in the near term or the long term.

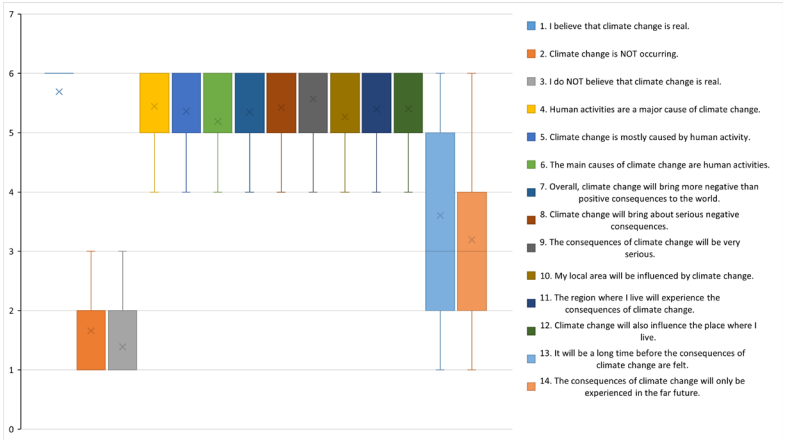

Figure 2. Perceptions of High School Students on Climate Change, Where X Mark Indicates the Mean

The results highlight students' engagement in environmental actions, categorized into participatory and leadership actions (Figure 3). Participatory actions involve participating in community events and talking with others about environmental issues (Alisat & Riemer, 2015). Among these, item 1 (M = 3.231, SD = 0.676) represents the most frequently performed action, indicating that educating oneself about environmental issues is a common practice among students. Parallel to these findings, a separate study also found that although more than half of the

students believed education played a role in decreasing global warming, less than a third of the students overall desired to educate themselves about the environment (Boyes et al., 2009). Similarly, common mitigation actions suggested by the students include raising awareness about the damage caused by climate change (Tunji-Olayeni et al., 2021). Having adequate knowledge of climate change can enable many young people to contribute and engage practically in the climate change discourse.

Other participatory actions, such as talking with others about environmental issues (Item 4, M = 2.951, SD = 0.846) and using online tools to raise awareness (Item 5, M = 2.731, SD = 0.957), also received moderate scores, suggesting that students engage in discussions and digital activism to some extent. However, financial support for environmental causes (Item 9, M = 2.040, SD = 0.945) and conscious time allocation for environmental activities (Item 14, M = 1.904, SD = 0.908) were among the lower-rated participatory actions, indicating less commitment to actions requiring monetary or long-term dedication. Similarly, in a case study from Turkey, the findings reveal that students explicitly displayed climate-friendly behaviors, such as informing others about climate change, while developing action competence through knowledge construction, dissemination of knowledge, and experiencing action (Tasti & Akar, 2021).

Leadership actions are commonly understood as environmental activism, which includes organizing a boycott, and generally received lower mean scores than participatory actions (Alisat & Riemer, 2015). The lowest mean among leadership actions was observed in item 11 (M = 1.343, SD = 0.749), which involved writing to or calling a government official. Similarly, organizing educational events (M = 1.870, SD = 0.902) and leading boycotts (M = 1.605, SD = 0.900) were not common actions among students, reflecting hesitancy in taking on leadership roles. The highest mean among leadership actions was found in item 6 (M = 1.923, SD = 0.936), suggesting that some students do take traditional actions such as writing letters or articles. However, the overall trend indicates that leadership engagement in environmental activism remains low among high school students. In contrast, recent studies have shown that youth view themselves as role models for younger members and express a willingness to incorporate environmentally supportive activities into regular youth movement activities (Goldman et al., 2017). In addition, despite the success of the youth movement in 2018-2019 in drawing attention to climate change as a critical global issue and reminding the world to include youth voices in global climate governance, the youth movement was unable to enact immediate policy changes as they were limited in translating their moral authority and legitimacy into power (Han & Ahn, 2020). This means that youth engagement in environmental activism remains low, as they are aware that they have limited power to effect change.

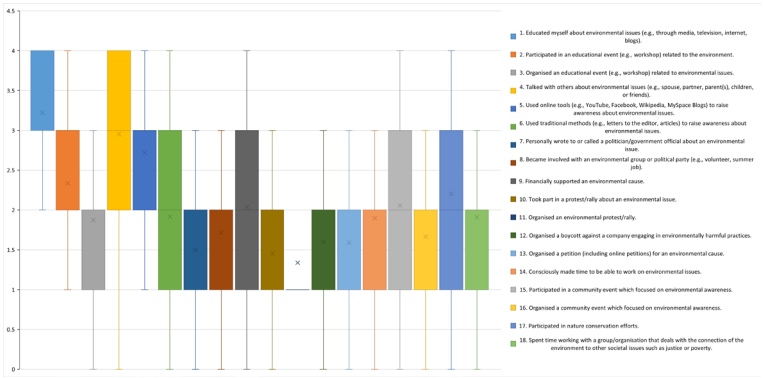

Figure 3. Environmental Actions of High SchoolSttudents Regrading Climate Change. The x Mark Indicates for the Mean

The results from Figure 4 provide insights into students' hope regarding climate change solutions, categorized into personal-sphere will and way, collective-sphere will and way, and lack of will and way. The personal sphere will and way include items that reflect students' perceptions of solving individual problems (Li & Monroe, 2018). Among these, item 5 (M = 5.312, SD = 0.839) received one of the highest mean scores, indicating a strong willingness among students to take individual actions to mitigate climate change. Item 7 (M = 5.182, SD = 0.891) further supports this trend, with students expressing confidence in their ability to take meaningful action (Figure 3, H7). Item 8 (M = 4.667, SD = 1.029) exhibits a slightly lower mean compared to items 5 and 7, with a more normally distributed response pattern, as indicated by its low skewness and

kurtosis. This suggests that while students generally believe in their own knowledge of how to act, the confidence level is not as strong as their willingness to take action. This low confidence in students' willingness to act could be due to the notion that willingness to adopt pro-climatic behavior presupposes a clear and explicit understanding of climate dynamics and its causal relations (Kolenatý et al., 2022). This means that without an increase in knowledge about mitigative actions, significant changes in willingness to act are unlikely (Tolppanen et al., 2022). In addition, willingness to take action is predicted by openness to change and a willingness to think deeply about issues (Sinatra et al., 2012). The findings highlight that climate hope requires knowledge and a clear understanding of climate change and its associated mitigative actions.

The collective sphere will and way reflects students' belief in the power of collective action in addressing climate change. The highest mean score in this aspect was found in item 4 (M = 5.472, SD = 0.815), which expresses confidence in the effectiveness of collective efforts. This kind of hope is important as climate change cannot be solved by one person alone, but only at a collective level (Ojala, 2012). This source of hope also appears to serve as a motivational force, and thus does not imply that one places all the responsibility for solving the problem solely on other actors.

Item 2, which is also evident in Figure 4 (M = 4.833, SD = 0.936) and Item 1 (M = 4.648, SD = 1.099), further reinforces the belief that scientists and the general public can collectively address climate change issues. However, their higher variance (0.876 and 1.207, respectively) suggests more variability in students' confidence in external problem-solving efforts. This indicates a lack of trust in science, which could be due to its questionable neutrality, academic ivory towers, and the myth of technological progress (Vandaele & Stålhammar, 2022). Hence, it is essential to foster students' trust in academia by aligning the university's values with those of its students in the long term. Item 6 (M = 4.836, SD = 1.102) aligns with these results, reflecting a belief that more people are willing to act, though its variance (1.215) suggests some level of skepticism among respondents. Item 3 (M = 5.219, SD = 0.875) reflects the belief that even if some individuals lose hope, others will persist in addressing climate change. Vandaele and Stålhammar (2022) also found that while younger generations recognized a rising awareness among peers, they also have doubts about whether this awareness translates into action. Moreover, while there is significant skepticism surrounding private sector actors, they have a solid trust in the potential of nongovernmental environmental organizations.

A lack of will and way represents a sense of hopelessness or a perceived inability to contribute effectively to climate change solutions. The lowest mean scores were observed in this group, indicating that most students reject the notion that they are powerless in addressing climate change. Item 9 (M = 2.485, SD = 1.498), which states that climate change is beyond personal control, has a positive skew, indicating that fewer students agree with this statement. However, the relatively high variance (2.244) suggests that some students still struggle with feelings of helplessness. Items 10 (M = 2.849, SD = 1.507) and 11 (M = 3.448, SD = 1.540) exhibit similar patterns, with low means and positive skewness. These results indicate that while most students believe that solutions exist, a subset of respondents still perceives climate change as an overwhelming challenge. Similar findings were reported by Li and Monroe (2018) who found that students slightly disagree that climate change is too complex to solve. The complex climate change issues of mitigation and adaptation are conceptually challenging for children, as climate change is not directly evident in their daily lives (Ratinen, 2021). Hence, it is essential to help young people in their late teens and early adulthood develop a more nuanced understanding of the complexity and dilemmas associated with climate change (Ojala, 2012).

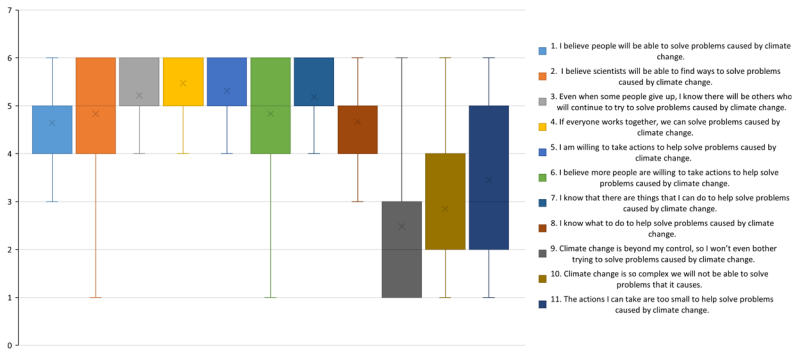

Figure 4. Climate Change Hope of High School Students. The x Mark Shows the Mean

Each latent variable has multiple indicators with varying factor loadings, reflecting their strength of association with the underlying construct. Hope is measured by four indicators, with H10 and H9 showing strong negative loadings, while H7 and H2 have weaker associations, suggesting they may not be as strong in defining the construct. Similarly, action is measured by four indicators, with A7, A10, and A18 demonstrating strong relationships, while A1 has a weaker relationship to the construct. For perception, P1, P5, and P8 have moderate to strong positive loadings, but P13 shows weaker or negative associations with the construct.

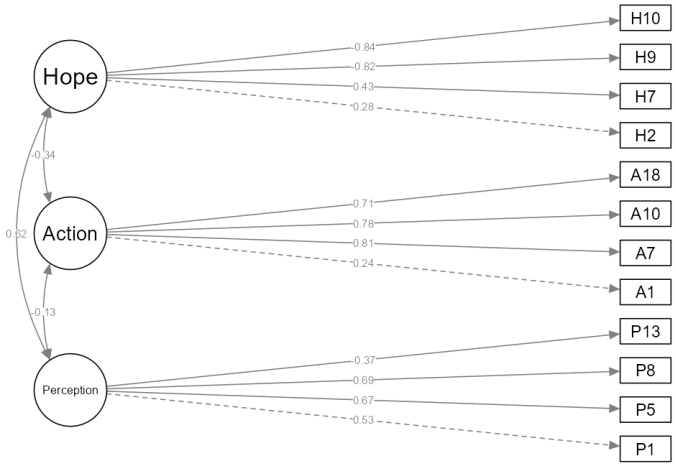

Figure 5. Structural Equation Model (SEM) Diagram Illustrating the Relationships between Three Latent Variables, such as Climate Change Hope, Action, and Perception, and Their Respective Observed Indicators

H2 and H7 correspond to students' beliefs in the power of collective action and their perceptions of solving individual problems, respectively. H9 and H10 both belong to the sense of hopelessness. A1 and A18 indicate participatory action, while A7 and A10 are about leadership actions. Lastly, P1 addresses the reality of climate change, P5 explores the causes of climate change, P8 examines the value of consequences, and P13 considers the temporal distance of consequences.

Importantly, the relationships between the latent variables reveal that perception and hope are positively correlated, indicating that higher levels of hope are associated with higher levels of perception. However, hope and action, as well as perception and action, exhibit weak to moderate negative correlations, suggesting that as hope and perception increase, action may decrease slightly. In a similar path analysis, knowledge and understanding of climate change and its impact on climate systems were found to be correlated with hope (Li & Monroe, 2019). Knowledge of the impacts of climate change, social norms, value orientations, affect, and personal experience with extreme weather events are significant predictors of climate change risk perception and climate change hope (Castellini et al., 2024). However, the negative correlation between hope and action, as well as perception and action, was expected. Studies have found that climate change risk perception does not directly predict pro-environmental behavior (Bradley et al., 2020), suggesting that knowledge alone cannot sufficiently promote positive action. On the other hand, similar findings reveal that hope alone was not related to climate action (Ojala, 2008). A combination of knowledge, hope, and worry can activate climate action, such as a willingness to pay for green energy (Pleeging et al., 2021; Sangervo et al., 2022). The findings suggest that while hope and perception are positively correlated, both show weak to moderate negative correlations with action, implying that higher levels of hope and perception alone may not directly drive pro-environmental behavior. Instead, a combination of knowledge, hope, and worry appears to be more effective in motivating climate action.

The indirect effect, which represents the effect of perception on action through hope, is not statistically significant, suggesting that the mediation effect of hope is marginal ($p = 0.052$). The percentage of mediation explained by this path is 25.7%, meaning that approximately one-quarter of the total effect is accounted for by the mediator. The direct effect (c), which measures the perception's impact on the action independent of the mediator, has an estimate of 0.1180 with a p-value of 0.053.

Table 1. Mediation Estimates Highlighting the Indirect, Direct, and Total Effects of Perception to Action through Hope

Effect	Label	Estimate	SE	95% Confidence Interval		Z	p	% Mediation
				Lower	Upper			
Indirect	a × b	0.0409	0.0210	0.00648	0.0915	1.94	0.052	25.7
Direct	c	0.1180	0.0610	-0.00587	0.2302	1.93	0.053	74.3
Total	c + a × b	0.1589	0.0620	0.03031	0.2775	2.56	0.010	100.0

The indirect effect, which represents the effect of perception on action through hope, is not statistically significant, suggesting that the mediation effect of hope is marginal ($p = 0.052$). The percentage of mediation explained by this path is 25.7%, meaning that approximately one-quarter of the total effect is accounted for by the mediator. The direct effect (c), which measures the perception's impact on the action independent of the mediator, has an estimate of 0.1180 with a p-value of 0.053. The direct effect contributes 74.3% of the total effect, indicating that most of the relationship between perception and action occurs directly, rather than through the mediator. The total effect, which combines both direct and indirect effects, is statistically significant ($p = 0.010$). This means that while the individual direct and indirect effects may not be strongly significant on their own, their combined impact is meaningful. These findings support the notion that perception alone cannot motivate climate action, but rather that the combination of hope and perception can lead to climate action and pro-environmental behavior. This further suggests that perception influences action primarily through hope, meaning hope acts as an important mediator in this relationship. This means that hope is important for people who have a relatively limited understanding of the climate change issue (Pleeging et al., 2021). The mediating role of hope was also evident in the study of Maartensson and Loi (2022) which found that constructive hope moderates the relationship between behavioral willingness and pro-environmental behavior, indicating that individuals who are willing to change their behavior in a more pro-environmental direction are more likely to do so if they are more hopeful. This idea strengthens the importance of designing environmental education programs that promote hope (Kerret et al., 2016). Therefore, science educators should focus on improving students' understanding of climate change, particularly those who indicate that they do not grasp the issue very well. Moreover, the science education curriculum should be framed in a way that promotes positive hope in the context of climate change. Interestingly, these findings contribute to a growing body of literature that narrows the attitude-behavior gap in climate change action (Maartensson & Loi, 2022).

CONCLUSION

The findings of this study underscore a strong agreement among students regarding the reality of climate change, its anthropogenic causes, and its serious consequences. However, there are variations in perceptions about the immediacy of climate change consequences. Students are also more inclined toward participatory environmental actions, while demonstrating minimal involvement in leadership-oriented activism. In addition, students exhibit strong personal and collective hope for the climate, although confidence in knowledge and external actors shows variability. These findings suggest that, despite increasing awareness and a sense of responsibility, students' limited leadership engagement reveals a persistent disconnect between environmental concern and taking empowered action. Moreover, the presence of uncertainty and perceived complexity among some students highlights the importance of deepening climate literacy and rebuilding trust in solutions to cultivate sustained and transformative engagement. The structural equation modeling results further reveal a positive correlation between perception and hope. However, there is a weak to moderate negative correlation between perception and action, as well as hope and action. Mediation analysis supports this conclusion, showing that hope plays a marginal role in linking perception to action, emphasizing the need for additional motivational factors to translate awareness into tangible pro-environmental behavior. The implications of these findings for climate change education are significant. While knowled-

ge and awareness are fundamental components of climate literacy, they do not necessarily lead to climate action. Climate change education should not only provide scientific knowledge but also incorporate pedagogical strategies that empower students to see themselves as active participants in climate solutions. The presence of climate hope is an essential factor in motivating students to engage in pro-environmental behavior, yet this study suggests that hope alone is insufficient. Therefore, science education, specifically climate change education, should be structured to bridge the attitude-behavior gap by integrating discussions that promote hope in science instruction, which could provide more opportunities for active participation in climate-related initiatives.

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REFERENCES

Ahmed, K. J., Chowdhury, M. T. A., Ahmed, M. N. Q., & Haq, S. M. A. (2021). Understanding climate change perception of teachers and students: An overview. In G. M. M. Alam, M. O. Erdiaw-Kwasie, G. J. Nagy, & W. Leal Filho (Eds.), *Climate vulnerability and resilience in the global south: Human adaptations for sustainable futures* (pp. 395–408). Springer International Publishing.

Alakbarov, A., & Hajiyeva, A. (2025). The environmental harms of greenhouse gas emissions: An interdisciplinary assessment. *Journal of Economics and Management Advances, 1*(1), 46–67.

Alisat, S., & Riemer, M. (2015). The environmental action scale: Development and psychometric evaluation. *Journal of Environmental Psychology, 43*, 13–23.

Armstrong, A. K., & Krasny, M. E. (2020). Tracing paths from research to practice in climate change education. *Sustainability, 12*(11), Article 11.

Azeiteiro, U. M., Bacelar-Nicolau, P., Santos, P. T., Bacelar-Nicolau, L., & Morgado, F. (2018). Assessing high school student perceptions and comprehension of climate change. In W. Leal Filho, E. Manolas, A. M. Azul, U. M. Azeiteiro, & H. McGhie (Eds.), *Handbook of climate change communication: Vol. 3. Case studies in climate change communication* (pp. 21–34). Springer International Publishing.

Baldwin, C., Pickering, G., & Dale, G. (2023). Knowledge and self-efficacy of youth to take action on climate change. *Environmental Education Research, 29*(11), 1597–1616.

Bhowmik, J., Irfanullah, H. M., Selim, S. A., & Budrudzaman, M. (2024). Assessing climate change-induced losses and damages to coastal ecosystem services: Empirical evidence from Manpura Island, Bangladesh. *Climate Risk Management, 45*, 100641

Bollettino, V., Alcayna-Stevens, T., Sharma, M., Dy, P., Pham, P., & Vinck, P. (2020). Public perception of climate change and disaster preparedness: Evidence from the Philippines. *Climate Risk Management, 30*, 100250.

Bouman, T., Steg, L., & Perlaviciute, G. (2021). From values to climate action. *Current Opinion in Psychology, 42*, 102–107.

Boyes, E., Skamp, K., & Stanisstreet, M. (2009). Australian secondary students' views about global warming: Beliefs about actions, and willingness to act. *Research in Science Education, 39*(5), 661–680.

Bradley, G. L., Babutsidze, Z., Chai, A., & Reser, J. P. (2020). The role of climate change risk perception, response efficacy, and psychological adaptation in pro-environmental behavior: A two nation study. *Journal of Environmental Psychology, 68*, 101410.

Brügger, A., Morton, T. A., & Dessai, S. (2015). Hand in hand: Public endorsement of climate change mitigation and adaptation. *PLOS ONE, 10*(4), e0124843.

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W. L., Connors, S., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., … Péan, C. (2023). *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H. Lee & J. Romero, Eds.). IPCC.

Castellini, G., Pinel, H., Acampora, M., Lucini, L., Barello, S., & Castiglioni, C. (2024). Understanding the role of hope in climate change risk perception: A cross-sectional study. *Journal of Risk Research, 27*(7), 789–805.

Duchenne-Moutien, R. A., & Neetoo, H. (2021). Climate change and emerging food safety issues: A review. *Journal of Food Protection, 84*(11), 1884–1897.

Elver, H., & Oral, N. (2021). Food security, fisheries and ocean acidification: A human rights-based approach.

Ettinger, J., Walton, P., Painter, J., & DiBlasi, T. (2021).

Climate of hope or doom and gloom? Testing the climate change hope vs. fear communications debate through online videos. *Climatic Change, 164*(1), 19.

Finnegan, W., & d'Abreu, C. (2024). The hope wheel: A model to enable hope-based pedagogy in climate change education. *Frontiers in Psychology, 15*.

Fritze, J. G., Blashki, G. A., Burke, S., & Wiseman, J. (2008). Hope, despair and transformation: Climate change and the promotion of mental health and wellbeing. *International Journal of Mental Health Systems, 2*(1), 13.

Geiger, N., Gasper, K., Swim, J. K., & Fraser, J. (2019). Untangling the components of hope: Increasing pathways (not agency) explains the success of an intervention that increases educators' climate change discussions. *Journal of Environmental Psychology, 66*, 101366.

Geng, M., Li, X., Mu, H., Yu, G., Chai, L., Yang, Z., Liu, H., Huang, J., Liu, H., & Ju, Z. (2023). Human footprints in the global south accelerate biomass carbon loss in ecologically sensitive regions. *Global Change Biology, 29*(20), 5881–5895.

Goldman, D., Pe'er, S., & Yavetz, B. (2017). Environmental literacy of youth movement members: Is environmentalism a component of their social activism? *Environmental Education Research*.

Gulzar, A., Islam, T., Gulzar, R., & Hassan, T. (2021). Climate change and impacts of extreme events on human health: An overview. *Indonesian Journal of Social and Environmental Issues (IJSEI), 2*(1), 68–77.

Han, H., & Ahn, S. W. (2020). Youth mobilization to stop global climate change: Narratives and impact. *Sustainability, 12*(10), Article 10.

Haq, S. M. A., & Ahmed, K. J. (2020). Perceptions about climate change among university students in Bangladesh. *Natural Hazards, 103*(3), 3683–3713.

Jakučionytė-Skodienė, M., & Liobikienė, G. (2021). Climate change concern, personal responsibility and actions related to climate change mitigation in EU countries: Cross-cultural analysis. *Journal of Cleaner Production, 281*, 125189.

Jamshidi, O., Asadi, A., Kalantari, K., & Azadi, H. (n.d.). Perception, knowledge, and behavior towards climate change: A survey among agricultural professionals in Hamadan Province, Iran.

Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research, 3*(2), 163–178.

Johnson, J. E., Welch, D. J., van Hooidonk, R., Tracey, D., Chandrasa, G., Molinari, B., Triani, D., Tania, C., & Susanto, H. (2023). Climate change implications for the Arafura and Timor Seas region: Assessing vulnerability of marine systems to inform management and conservation. *Climatic Change, 176*(7), 88.

Jones, C. A., & Davison, A. (2021). Disempowering emotions: The role of educational experiences in social responses to climate change. *Geoforum, 118*, 190–200.

Kang, J., & Tolppanen, S. (2024). Exploring the role of science education as a catalyst for students' willingness to take climate action. *International Journal of Science Education*, Advance online publication.

Kerret, D., Orkibi, H., & Ronen, T. (2016). Testing a model linking environmental hope and self-control with students' positive emotions and environmental behavior. *The Journal of Environmental Education, 47*(4), 307–317.

Kolenatý, M., Kroufek, R., & Činčera, J. (2022). What triggers climate action: The impact of a climate change education program on students' climate literacy and their willingness to act. *Sustainability, 14*(16), Article 16.

Korkmaz, M. (2018). Public awareness and perceptions of climate change: Differences in concern about climate change in the West Mediterranean region of Turkey. *Applied Ecology and Environmental Research, 16*(4), 4039–4050.

Kovács, L. N., Jordan, G., Berglund, F., Holden, B., Niehoff, E., Pohl, F., Younssi, M., Zevallos, I., Ágoston, C., Varga, A., & Kökönyei, G. (2024). Acting as we feel: Which emotional responses to the climate crisis motivate climate action. *Journal of Environmental Psychology, 96*, 102327.

Krafft, A. M., Guse, T., & Maree, D. (2020). Distinguishing perceived hope and dispositional optimism: Theoretical foundations and empirical findings beyond future expectancies and cognition. *Journal of Well-Being Assessment, 4*(3), 217–243.

Kundariati, M., Ibrohim, I., Rohman, F., Nida, S., Hayuana, W., & Putra, Z. A. Z. (2024). Exploring students' climate change perception: The key factor of climate change mitigation and adaptation. *JPBI (Jurnal Pendidikan Biologi Indonesia), 10*(1), 185–194.

Kurup, P. M., Levinson, R., & Li, X. (2021). Informed-decision regarding global warming and climate change among high school students in the United Kingdom. *Canadian Journal of Science, Mathematics and Technology Education, 21*(1), 166–185.

Kuthe, A., Keller, L., Körfgen, A., Stötter, H., Oberrauch, A., & Höferl, K.-M. (2019). How many young generations are there? A typology of teenagers' climate change awareness in Germany and Austria. *The Journal of Environmental Education, 50*(3), 172–192.

Li, C. J., & Monroe, M. C. (2019). Exploring the essential psychological factors in fostering hope concerning climate change. *Environmental Education Research, 25*(6), 936–954.

Li, C., & Monroe, M. C. (2018). Development and validation of the climate change hope scale for high school students. *Environment and Behavior, 50*(4), 454–479.

Lincoln, S., Buckley, P., Howes, E. L., Maltby, K. M.,

Pinnegar, J. K., Ali, T. S., Alosairi, Y., Al-Ragum, A., Baglee, A., Balmes, C. O., Hamadou, R. B., Burt, J. A., Claereboudt, M., Glavan, J., Mamiit, R. J., Naser, H. A., Sedighi, O., Shokri, M. R., Shuhaibar, B., ... Le Quesne, W. J. F. (2021). A regional review of marine and coastal impacts of climate change on the ROPME sea area. *Sustainability, 13*(24), 13810.

Liu, Y., Song, Y., & Wang, X. (2022). Increasing preservice science teachers' climate change knowledge, hope, and self-efficacy in an online chemistry course. *Journal of Chemical Education, 99*(7), 2465–2473.

Liu, S., Wu, T., Wang, X., Wu, X., Yao, X., Liu, Q., ... & Zhu, X. (2021). Changes in the global cryosphere and their impacts: A review and new perspective. *Sciences in Cold and Arid Regions, 12*(6), 343-354.

Maartensson, H., & Loi, N. M. (2022). Exploring the relationships between risk perception, behavioural willingness, and constructive hope in pro-environmental behaviour. *Environmental Education Research, 28*(4), 600–613.

Marlon, J. R., Bloodhart, B., Ballew, M. T., Rolfe-Redding, J., Roser-Renouf, C., Leiserowitz, A., & Maibach, E. (2019). How hope and doubt affect climate change mobilization. *Frontiers in Communication, 4*.

Masud, M. M., Akhtar, R., Afroz, R., Al-Amin, A. Q., & Kari, F. B. (2015). Pro-environmental behavior and public understanding of climate change. *Mitigation and Adaptation Strategies for Global Change, 20*(4), 591–600.

Mensah, J. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences, 5*(1), 1653531.

Mirón, I. J., Linares, C., & Díaz, J. (2023). The influence of climate change on food production and food safety. *Environmental Research, 216*, 114674.

Mochizuki, Y., & Bryan, A. (2015). Climate change education in the context of education for sustainable development: Rationale and principles. *Journal of Education for Sustainable Development, 9*(1), 4–26.

Molthan-Hill, P., Worsfold, N., Nagy, G. J., Leal Filho, W., & Mifsud, M. (2019). Climate change education for universities: A conceptual framework from an international study. *Journal of Cleaner Production, 226*, 1092–1101.

Monroe, M. C., Oxarart, A., & Plate, R. R. (2013). A role for environmental education in climate change for secondary science educators. *Applied Environmental Education & Communication, 12*(1), 4-18.

Nimma, D., Devi, O. R., Laishram, B., Ramesh, J. V. N., Boddupalli, S., Ayyasamy, R., Tirth, V., & Arabil, A. (2025). Implications of climate change on freshwater ecosystems and their biodiversity. *Desalination and Water Treatment, 321*, 100889.

Ojala, M. (2008). Recycling and ambivalence: Quantitative and qualitative analyses of household recycling among young adults. *Environment and Behavior, 40*(6), 777-797.

Ojala, M. (2012). Hope and climate change: The importance of hope for environmental engagement among young people. *Environmental Education Research, 18*(5), 625–642.

Ojala, M. (2023). Hope and climate-change engagement from a psychological perspective. *Current Opinion in Psychology, 49*, 101514.

Pickering, G. J., Schoen, K., Botta, M., & Fazio, X. (2020). Exploration of youth knowledge and perceptions of individual-level climate mitigation action. *Environmental Research Letters, 15*(10), 104080.

Ponto, J. (2015). Understanding and evaluating survey research. *Journal of the Advanced Practitioner in Oncology, 6*(2), 168–171.

Ratinen, I. (2021). Students' knowledge of climate change, mitigation and adaptation in the context of constructive hope. *Education Sciences, 11*(3).

Reid, A. (2019). Climate change education and research: Possibilities and potentials versus problems and perils? *Environmental Education Research, 25*(6), 767–790.

Rocque, R., Beaudoin, C., Ndjaboue, R., Cameron, L., Poirier-Bergeron, L., Poulin-Rheault, R.-A., Fallon, C., Tricco, A., & Witteman, H. (2025). Health effects of climate change: An overview of systematic reviews. *BMJ Open*.

Sangervo, J., Jylhä, K. M., & Pihkala, P. (2022). Climate anxiety: Conceptual considerations, and connections with climate hope and action. *Global Environmental Change, 76*, 102569.

Sinatra, G. M., Kardash, C. M., Taasoobshirazi, G., & Lombardi, D. (2012). Promoting attitude change and expressed willingness to take action toward climate change in college students. *Instructional Science, 40*(1), 1–17.

Smith, N., & Leiserowitz, A. (2014). The role of emotion in global warming policy support and opposition. *Risk Analysis, 34*(5), 937–948.

Snyder, C. R., Rand, K. L., & Sigmon, D. R. (2001). Hope theory: A member of the positive psychology family. In C. R. Snyder & S. J. Lopez (Eds.), *Handbook of positive psychology* (p. 0). Oxford University Press.

Stahlmann-Brown, P., Swerdloff, S., & Wesselbaum, D. (2025). Climate belief, accuracy of climatic expectations, and pro-environmental action. *Environmental Hazards, 24*(3), 268–289.

Steg, L., Bolderdijk, J. W., Keizer, K., & Perlaviciute, G. (2014). An integrated framework for encouraging pro-environmental behaviour: The role of values, situational factors and goals. *Journal of Environmental Psychology, 38*, 104–115.

Stern, P. C. (2000). New environmental theories: Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues, 56*(3), 407–424.

Tolppanen, S., Claudelin, A., & Kang, J. (2021). Preservice teachers' knowledge and perceptions of the impact of mitigative climate actions and their willingness to act. *Research in Science Education, 51*(6), 1629–1649.

Tolppanen, S., Kang, J., & Riuttanen, L. (2022). Changes in students' knowledge, values, worldview, and willingness to take mitigative climate action after attending a course on holistic climate change education. *Journal of Cleaner Production, 373*, 133865.

Trenberth, K. E. (2018). Climate change caused by human activities is happening and it already has major consequences. *Journal of Energy & Natural Resources Law, 36*(4), 463–481.

Tunji-Olayeni, P., Adegboye, F., Oluwatobi, A., Adeyemi, G., Olagunju, O., Okoro, A., & Osabuohien, E. (2021). Accelerating progress on sustainable development goals: Assessing secondary school students' knowledge of climate change actions. *IOP Conference Series: Earth and Environmental Science, 665*(1), 012041.

UNDP. (2024, June 20). The world's largest survey on climate change is out – here's what the results show. *UNDP Climate Promise*. https://climatepromise.undp.org

van Baal, K., Stiel, S., & Schulte, P. (2023). Public perceptions of climate change and health—A cross-sectional survey study. *International Journal of Environmental Research and Public Health, 20*(2), 1464.

van der Linden, S. (2017). Determinants and measurement of climate change risk perception, worry, and concern. *Social Science Research Network*.

van Valkengoed, A. M., Steg, L., & Perlaviciute, G. (2021). Development and validation of a climate change perceptions scale. *Journal of Environmental Psychology, 76*, 101652.

Vandaele, M., & Stålhammar, S. (2022). "Hope dies, action begins?" The role of hope for proactive sustainability engagement among university students. *International Journal of Sustainability in Higher Education, 23*(8), 272–289.

Visschers, V. H. M. (2018). Public perception of uncertainties within climate change science. *Risk Analysis, 38*(1), 43–55.

Wang, S. (2024). Opportunities and threats of cryosphere change to the achievement of UN 2030 SDGs. *Humanities and Social Sciences Communications, 11*(1), 44.

Weber, E. U., & Constantino, S. M. (2023). All hearts and minds on deck: Hope motivates climate action by linking the present and the future. *Emotion Review, 15*(4), 293–297.

White, P. J., Ardoin, N. M., Eames, C., & Monroe, M. C. (2023). Agency in the Anthropocene: Supporting document to the PISA 2025 science framework. *OECD Education Working Papers, 297*.

Wildbichler, S., Haagen-Schützenhöfer, C., & Schubatzky, T. (2025). Students' ideas about the scientific underpinnings of climate change: A systematic review of the literature. *Studies in Science Education, 61*(1), 117–169.

Wudu, K., Abegaz, A., Ayele, L., & Ybabe, M. (2023). The impacts of climate change on biodiversity loss and its remedial measures using nature-based conservation approach: A global perspective. *Biodiversity and Conservation, 32*(12), 3681–3701.

Yao, Y., Liu, Y., Fu, F., Song, J., Wang, Y., Han, Y., Wu, T., & Fu, B. (2024). Declined terrestrial ecosystem resilience. *Global Change Biology, 30*(4), e17291.

Tasti, O. Y., & Akar, H. (2021). Promoting climate-friendly actions of high school students: A case from Turkey. *Eurasian Journal of Educational Research*.

Zhou, S., Liu, B., Wang, J., Jin, D., & Zhang, H. (2025). Assessing global agricultural greenhouse gas emissions: Key drivers and mitigation strategies. *Agronomy, 15*(6), 1336.