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ORIGINAL ARTICLE

Exploring Vietnamese Pre-Service Teachers' Knowledge, Attitudes, Beliefs, and Teaching Intentions Regarding Climate Change

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ABSTRACT
Climate change presents significant global challenges and is a top priority for many countries, including Vietnam, in achieving sustainable development goals. Teachers' perceptions of climate change strongly influence their teaching and ability to inspire students to take actions. This study examines the knowledge, attitudes, beliefs, and teaching intentions of Vietnamese pre-service teachers regarding climate change through a survey of 468 participants from teacher education institutions nationwide. Research findings reveal that while pre-service teachers have some understanding of climate change, their knowledge remains limited. Although most express a willingness to act, their beliefs about climate change are often ambiguous and inconsistent. This study represents the first large-scale survey in Vietnam on this topic, providing implications for teacher education programs. Specifically, integrating climate change education as a mandatory course or shared module, incorporating experiential learning, ensuring access to updated research, and enhancing institutional support are crucial for strengthening pre-service teachers' knowledge and confidence in educating about climate change.

1. INTRODUCTION

According to the Climate Risk Index, Vietnam ranked sixth among the ten countries most heavily affected by climate change (CC) in 2017 (Eckstein et al., 2018). CC has become a global challenge, garnering significant attention from governments, international organizations, and researchers (IPCC, 2022; Wang et al., 2020). In recent decades, CC education has emerged as a critical research focus to raise awareness and promote responsive actions (Monroe et al., 2019).

In Vietnam, addressing CC is recognized as a priority for achieving sustainable development goals (National Assembly, 2020). Research on CC perception in the country highlights varying levels of awareness among different population groups. A study in Ho Chi Minh City claims that residents are aware of climate change and willing to support mitigation policies, especially when they perceive its negative consequences as severe (Thang, 2013). Several studies have examined university undergraduates' perceptions of CC and its health impacts (Hien et al., 2019; Ka & Ngoc, 2023). These studies covering multiple universities, including those in Hue and Da Nang, indicate that while undergraduates recognize CC and adopt some adaptation measures, their practical engagement remains limited.

These findings suggest a need for targeted educational efforts to enhance public understanding, particularly regarding specific impacts and effective responses.

In alignment with the 2030 Agenda of Vietnam (PM & Gov Viet, 2017), the Ministry of Education and Training (MOET) introduced the Plan for Implementing Sustainable Development in the Education and Training Sector through 2025, with a vision extending to 2030 (MOET, 2017). This plan underscores the importance of integrating Education for Sustainable Development and its related topics, such as CC, at all levels of education, as well as the demand for qualified teachers to achieve this goal. Accordingly, teacher education programs have incorporated CC content in various ways, particularly in disciplines such as Geography, Biology, and Chemistry (Nguyen, 2023). Teachers' knowledge and beliefs play a crucial role in the effective implementation of educational policies (Rahman et al., 2018). International studies have shown that teachers' perceptions, knowledge, attitudes, and beliefs about CC significantly influence their teaching and ability to inspire students to take actions (Anderson, 2012). However, in Vietnam, research on this topic remains limited.

Given the crucial role of teachers' knowledge and beliefs in shaping students' understanding and actions, this study presents the first large-scale dataset on pre-service teachers' perspectives, drawing insights from 468 participants across Vietnam. By examining pre-service teachers' awareness, misconceptions, and readiness to teach CC-related topics, this study contributes valuable empirical evidence to inform teacher education programs. It highlights specific areas where knowledge gaps persist and identifies opportunities to enhance training curricula, ensuring that future teachers are better equipped to integrate CC education effectively. Furthermore, the study aligns with international research on the role of teachers in CC education while offering localized insights that are crucial for policy development and curriculum design in Vietnam.

2. LITERATURE REVIEW

2.1. Climate change

The United Nations Framework Convention on Climate Change (UNFCCC, 1992) defines CC as:

"A change of climate which is attributed directly or indirectly to human activities that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

Intergovernmental Panel on Climate Change (IPCC, 2007, p. 30) further defines CC as:

"A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activities").

2.2. Teachers' perceptions of CC

Regarding knowledge of CC, studies have identified existing gaps among teachers and pre-service teachers (Abasto et al., 2023; Herman et al., 2017; Nyarko & Petcovic, 2021; Papadimitriou, 2004; Seroussi et al., 2019). Researchers suggest that teachers and pre-service teachers often misunderstand the causes of climate change, mistakenly believing that ozone layer depletion or the greenhouse effect is the primary cause (Abasto et al., 2023; Nyarko & Petcovic, 2021; Papadimitriou, 2004; Seroussi et al., 2019). Teachers also confuse greenhouse gases with solar radiation and misunderstand the relationship between ozone layer depletion and the greenhouse effect (Abasto et al., 2023; Arslan et al., 2012).

Beyond misconceptions about the causes, teachers also hold inaccurate views regarding the consequences of climate change (Nayak, 2011; Seroussi et al., 2019). Both teachers and students demonstrate a lack of understanding of climate change, and shifting their perceptions on this issue proves to be challenging (Ratinen, 2016). Tolppanen et al. (2021) argue that pre-service teachers have limited knowledge of the impacts of climate change mitigation actions. However, another study (Dal et al., 2015) found that the teachers in a specific context exhibited a reasonable level of awareness regarding the causes, impacts, and trends of climate change.

Teachers' attitudes and beliefs about science play a crucial role in shaping students' perspectives on related topics, as teachers often adapt their teaching strategies to align with their own knowledge and beliefs (Duschl, 1990; Waters-Adams, 2006). Several studies indicate that teachers hold strong beliefs about various aspects of CC, particularly that

it is a global challenge requiring individual actions to address (Nation, 2017; Nation & Feldman, 2021, 2022). These beliefs are often shaped by the perspectives of educators and policymakers (Nation & Feldman, 2022).

Although addressing CC is a shared collective responsibility, many individuals mistakenly believe it is the sole responsibility of government agencies, such as the Ministry of Natural Resources and Environment, rather than their own. This misconception is also reflected among teachers (Lee et al., 2012) and students (Pettersson, 2014), a phenomenon often referred to as "delegation" (Kollmuss & Agyeman, 2002). Delegation is described as a mechanism for alleviating guilt and justifying inaction (Norgaard, 2011) with those who delegate being perceived as unwilling or unable to take actions requiring personal sacrifice (Kollmuss & Agyeman, 2002).

As a result, many teachers lack knowledge, subjective awareness, and effective teaching methods for addressing CC. This shortfall affects the beliefs, knowledge, and perceptions of future generations regarding CC. While education holds immense potential, it remains underutilized in the fight against CC (Anderson, 2012; Bangay & Blum, 2010; Fahey, 2018). Pre-service teachers and educators must therefore be equipped with in-depth, comprehensive knowledge about CC to understand it correctly and apply effective methods in their teaching.

Research that explores and evaluates the knowledge, beliefs, and attitudes of teachers (both in-service and pre-service) is crucial. Such studies can help develop strategies to ensure that teachers gain accurate awareness of global challenges like CC. Despite extensive international research, Vietnam lacks systematic studies on teachers' CC knowledge, attitudes, beliefs, and teaching intentions. This study, thus, aims to fill this gap by providing empirical data to inform teacher training practices through investigating the following research questions: What knowledge do pre-service teachers have about CC?; What are pre-service teachers' attitudes and beliefs regarding CC?; What topics do pre-service teachers show interest in when teaching about CC?

3. MATERIALS AND METHODS

3.1. Survey instrument

The study aimed to explore pre-service teachers' knowledge, attitudes, beliefs, and teaching intentions regarding CC. Data were collected via an online survey conducted using Google Forms, which included 14 questions designed to assess knowledge, attitudes, and teaching intentions related to CC. The survey questions, adapted from Nation (2017) and Wang et al. (2020), were chosen because these studies had been validated in various contexts. The authors specifically modified question B13 and C14 to align with the context of Vietnam. Specifically, in relation to question B13, the original questionnaire by Nation (2017) asks respondents to select from a list of eight actions that the U.S. government can take to help prevent global warming. In our survey instrument, question B13 was modified based on the Vietnamese government's Agenda 2030, replacing the original options with five actions relevant to Vietnam. Regarding question C14, we added the item "C14.13: Personal actions to mitigate the effects of climate change" because we believe it is important to address the role of personal actions in combating climate change. Including this aspect can help pre-service teachers think about fostering transformative changes in students' personal behavior. The survey consisted of: Open-ended questions: Two questions to gather qualitative insights about perceptions and attitudes; Closed-ended questions: Twelve multiple-choice, Likert-scale, and ranking questions.

The survey's reliability was confirmed through a pilot study involving 75 students from Hanoi National University of Education. Data were analyzed using the SPSS software, with Cronbach's alpha (α) and reliability values (ρ) exceeding 0.7, indicating high reliability.

3.2. Participants

The survey included 468 pre-service teachers in their 2nd, 3rd, and 4th years, specializing in Chemistry, Geography, History-Geography, Natural Sciences, Biology, and other disciplines across six teacher education institutions (TEIs). These institutions were: Hanoi National University of Education, University of Education – Vietnam National University, Hanoi, Hanoi Pedagogical University 2, Thai Nguyen University of Education, Da Nang University of Education, and Quy Nhon University. The survey was conducted from March to April, 2024.

3.3. Data analysis

Quantitative data were analyzed using descriptive statistics to calculate means and distributions, providing insights into participants' CC knowledge, attitudes, beliefs, and teaching intentions. Qualitative data were analyzed through content analysis.

For the question, "How do you understand climate change?", responses were categorized based on three criteria: (1) Correct: Provides a complete and accurate definition of CC according to the IPCC (2022) or the UNFCCC (1992); (2) Partially correct: Describes changes in specific climate factors but omits the aspect of a long time frame, or vice versa; (3) Incorrect: Demonstrates misconceptions or provides definitions unrelated to the concept of CC.

For the question, "Are you interested in learning about CC? If yes, why? If no, why not?", the data were analyzed using inductive categorization. Five categories emerged: Interested because CC is related to personal life; Interested due to a sense of responsibility toward sustainable development; Interested because it relates to both personal life and sustainable development; Lack of time to explore the topic; Not interested.

This approach helps clarify different aspects of pre-service teachers' perceptions of CC, providing insights for designing appropriate teacher education programs.

4. RESULTS AND DISCUSSION

4.1. General description of the participants

A total of 468 pre-service teachers from various TEIs participated in the survey (Table 1). Most participants had studied climate change (CC) or related topics, such as global warming, the greenhouse effect, and acid rain, as part of their training programs. However, the duration of study on these topics varied significantly among participants (Table 1).

Table 1. Study participants

Criteria		Percentage
Year of Study	Second-year students	36.97
	Third-year students	43.59
	Fourth-year students	19.44
Major	Chemistry Education	22.01
	History-Geography Education	14.74
	Natural Sciences	14.74
	Geography Education	27.56
	Biology Education	6.20
	Other Majors	14.74
Duration of Study	1-2 lessons (1 lesson = 40-50 minutes)	32.2
	3-5 lessons (1 lesson = 40-50 minutes)	25.2
	5-10 lessons (1 lesson = 40-50 minutes)	10.1
	A specialized course/module on CC	20.0
	Uncertain/Don't know	10.0
	No exposure to CC topics	2.5

4.2. Knowledge

The survey results reveal that only 23.55% of participants provided a correct definition of CC (Table 2). However, for some factual knowledge questions about CC, the percentage of correct answers exceeded 70% (Table 3). Regarding the causes of global warming, pre-service teachers primarily identified the use of personal vehicles and deforestation as the main contributors (Table 4). However, notable misconceptions persist, with a significant proportion of participants mistakenly identifying ozone layer depletion and fossil fuel use as direct causes of CC. These findings suggest that pre-service teachers' knowledge of CC remains limited and inconsistent.

Table 2. Pre-service Teachers' Definitions of Climate Change (%)

Question	Correct	Partially Correct	Incorrect
Question 1: How do you define climate change?	23.55	44.19	32.26

Table 3. Pre-service Teachers' Knowledge of Climate Change (%)

Question	Correct	Incorrect
Question 2: Which statement best describes the difference between climate and weather?	77.10	22.90
Question 3: What happens to seawater when carbon dioxide dissolves in the ocean?	71.94	28.06
Question 4: Which statement about global warming in the past 50 years is the most accurate?	72.58	27.42
Question 5: Which statement about air temperature changes over millions of years is most accurate?	21.61	78.39
Question 7: How does atmospheric carbon dioxide affect near-surface air temperature?	54.19	45.81
Question 8: Which definition best describes a greenhouse gas?	43.55	56.45
Question 9: How has atmospheric carbon dioxide changed since the Industrial Revolution 150 years ago?	78.06	21.94

Table 4. Pre-service Teachers' Knowledge of Causes of Global Warming (%)

Cause	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Use of personal vehicles (cars, motorbikes)	4.52	0.97	3.23	59.35	31.94
Ozone layer depletion	3.87	1.94	5.81	59.68	28.71
Fossil fuel use	3.23	1.94	10.32	55.16	29.35
Use of nuclear energy	3.23	4.52	11.29	56.13	24.84
Agricultural practices	7.42	19.68	24.19	36.77	11.94
Deforestation	3.23	1.94	3.87	47.42	43.55
Industrial production activities	3.23	2.26	4.19	52.90	37.42

The results indicate little variation in knowledge across fields of study, except for certain factors related to the causes of global warming, such as ozone layer depletion, fossil fuel use, and agricultural practices.

In general, the findings reveal that pre-service teachers have an inconsistent understanding of CC. While only about one-fourth provided an accurate definition of CC, participants correctly identified some causes of global warming. However, misconceptions persist - many mistakenly associated ozone layer depletion and fossil fuel use as direct causes of CC. These results highlight gaps in foundational knowledge and indicate the need for more targeted education on climate science.

4.3. Attitudes and beliefs

Pre-service teachers' beliefs about CC reveal notable inconsistencies (Table 5). Most pre-service teachers agreed (53.87%) or strongly agreed (35.16%) with the statement, "A large amount of data proves that CC is happening."

However, 41.29% also agreed with the statement, "Scientific methods for measuring CC lack the certainty to be trusted". Additionally, 62.90% agreed with the statement, "Science on CC provides predictions about the Earth's climate that can be scientifically verified".

Regarding pre-service teachers' attitudes toward CC, the survey indicated a relatively high level of interest, primarily driven by personal concerns (Table 6). When asked about actions to prevent global warming, the participants primarily selected individual actions, such as reducing personal vehicle use, planting trees, and raising awareness among others, while fewer opted for institutional-level changes (Table 7).

As for actions the Vietnamese government could take to address CC, most participants viewed measures such as public awareness campaigns, education, workforce development, and advancements in science and technology as highly important (Table 8).

Table 5. Pre-service Teachers' Beliefs About Climate Change (%)

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A large amount of data proves that climate change is happening.	5.81	0.00	5.16	53.87	35.16
Scientific methods to measure climate change are too uncertain to be reliable.	2.90	15.48	30.65	41.29	9.68
Science on CC provides predictions about Earth's climate that can be scientifically verified.	2.58	1.94	15.16	62.90	17.42
To be valuable, CC science must be based on controlled experiments.	4.19	2.26	10.00	61.61	21.94
Most CC knowledge is based on models, not scientifically substantiated ideas.	8.06	21.94	26.45	32.58	10.97
The climate changes we are experiencing are primarily due to natural processes (not human-induced).	16.45	20.97	14.19	37.10	11.29

Table 6. Pre-service Teachers' Interest in Climate Change

Level of Interest	Percentage
Interested because CC is related to personal life	55.1
Interested due to responsibilities toward sustainable development	18.3
Interested because of both personal life and responsibilities for development	8.7
Lack of time	2.2
Not interested	11.2
No idea	4.5

Table 7. Pre-service Teachers' Responses to the Importance of Actions to Prevent Global Warming

(1 = Most Important, 8 = Least Important) (%)

Action	1	2	3	4	5	6	7	8
Reducing the use of personal vehicles	39.0	6.5	13.2	7.1	8.1	8.1	5.2	12.9
Recycling	8.4	42.9	8.1	11.6	9.4	5.8	10.6	3.2

Using public transportation more frequently	2.3	8.7	40.3	13.2	10.6	14.2	5.5	5.2
Using clean and alternative energy	6.8	8.1	13.9	44.2	16.8	6.8	2.3	1.3
Planting trees	20.0	13.5	7.1	10.6	38.4	2.9	4.8	2.6
Raising awareness and educating others	10.6	7.4	11.9	7.1	8.7	43.9	6.1	4.2
Promoting political actions	3.5	8.4	3.5	2.9	4.2	8.7	41.9	26.8
Using less energy	9.4	4.5	1.9	3.2	3.9	9.8	23.5	43.9

Table 8. Pre-service Teachers' Response to Important Actions the Vietnamese Government Could Take to Address Climate Change (1 = Most Important, 5 = Least Important) (%)

Action	1	2	3	4	5
Actively raising public awareness	32.9	20.97	12.26	17.1	16.77
Developing a high-quality workforce for CC research and responses	18.71	23.55	24.19	15.81	17.74
Advancing science and technology; fostering research and innovations	23.55	23.55	24.52	18.06	10.32
Mobilizing financial resources	11.94	16.45	20.32	21.29	30.00
Strengthening international cooperation	12.90	15.50	18.70	27.70	25.20

The test results indicate little variation in attitudes and beliefs across disciplines, except for the statement "Scientific methods for measuring CC lack the certainty to be trusted," which showed a statistically significant difference (Table 9).

Table 9. Differences in attitudes and beliefs by field of discipline

Statement	Code	Sig
A large amount of data proves that climate change is happening.	A3.1	0.077
Scientific methods to measure climate change are too uncertain to be reliable.	A3.2	0.021
Science on CC provides predictions about Earth's climate that can be scientifically verified.	A3.3	0.100
To be valuable, CC science must be based on controlled experiments.	A3.4	0.063
Most CC knowledge is based on models, not scientifically substantiated ideas.	A3.5	0.193
The climate changes we are experiencing are primarily due to natural processes (not human-induced).	A3.6	0.311

Generally, these findings indicate that pre-service teachers hold inconsistent beliefs about CC. While most participants acknowledged the strong scientific evidence supporting CC, a significant proportion also expressed doubts concerning the reliability of climate science methods. Their attitudes reflected a relatively high level of personal interest in CC, mainly driven by concerns about its impact on their lives. When considering actions to prevent global warming, the participants prioritized individual efforts such as reducing personal vehicle use and planting trees over systemic or policy-driven measures. Similarly, they viewed public awareness campaigns, education, and advancements in science and technology as the most important governmental actions to address CC. Notably, attitudes and beliefs showed little variation across disciplines, except for skepticism regarding the certainty of climate science, which differed significantly by field of study.

4.4. Teaching intentions

When examining the teaching intentions of pre-service teachers regarding CC topics, we observed positive outcomes. Most participants expressed an interest in the impacts of CC on water resources and indicated an intention to promote this knowledge widely within their communities (>75%). Similarly, the proportion of participants intending to teach other CC-related topics was also relatively high. These findings highlight that pre-service teachers recognize the importance of CC and are eager to convey knowledge about it to students and the broader community (Table 10). The test results reveal significant differences in teaching intentions (variables B12.1, B12.3, B12.5, B12.7, B12.9, and B12.10) across different fields of discipline (Table 11).

Table 10. Level of intention to teach CC topics among pre-service teachers (%)

Topic	Integrate extensively	Integrate moderately	Integrate minimally	Do not teach
Disruption of the carbon cycle	17.1	43.9	34.2	4.8
Impact on water resources	41.9	45.2	10.6	2.3
Impact on local weather patterns	39.0	42.6	15.2	3.2
Impact on food supply	31.6	45.5	17.4	5.5
Impact on economic development	39.7	39.7	14.5	6.1
Sea level/ocean changes	35.8	46.5	14.2	3.5
Species adaptation	30.0	45.8	18.7	5.5
Impact on biodiversity and species distribution	39.0	42.6	13.9	4.5
Increase and complexity of diseases	43.5	38.7	14.8	2.9
Impact on socio-economic development	40.6	39.7	14.5	5.2
Providing evidence and data on CC	38.1	41.9	15.2	4.8
CC mitigation and adaptation	52.6	34.5	9.4	3.5
Personal actions to mitigate the impact of CC	55.2	33.9	6.8	4.2

Table 11. Differences in teaching intentions about CC among by field of disciplines

Statement	Code	Sig
Disruption of the carbon cycle	B12.1	0.000
Impact on water resources	B12.2	0.084
Impact on local weather patterns	B12.3	3.739
Impact on food supply	B12.4	1.685
Impact on economic development	B12.5	3.753
Sea level/ocean changes	B12.6	0.143
Species adaptation	B12.7	2.307
Impact on biodiversity and species distribution	B12.8	1.917

Increase and complexity of diseases	B12.9	2.734
Impact on socio-economic aspects	B12.10	3.474
Providing evidence and data on CC	B12.11	0.995
CC mitigation and adaptation	B12.12	0.298
Personal actions to mitigate the impact of CC	B12.13	0.221

The findings indicate that pre-service teachers have strong teaching intentions regarding CC. A majority expressed willingness to integrate CC topics into their teaching, with particular emphasis on the impacts of CC. Additionally, over half of participants intended to promote personal actions for CC mitigation. These results suggest that pre-service teachers recognize the importance of CC education and are eager to disseminate knowledge within schools and communities. However, significant differences in teaching intentions were observed across disciplines, highlighting the need for tailored approaches to support CC education in different subject areas.

4.5. Discussion

Persistent misconceptions and knowledge gaps in CC education

The survey results indicate that while pre-service teachers possess a basic awareness of CC, their understanding remains vague and inconsistent. This is evident in their responses to factual questions, where correct and incorrect answers were nearly equal, as well as in open-ended questions, where a significant proportion (32.26%) provided incorrect definitions and nearly half (44.19%) gave incomplete responses. These findings align with international studies on CC education, such as Seroussi et al. (2019).

The prevalence of misconceptions reflected in Vietnamese pre-service teachers, such as identifying ozone layer depletion and fossil fuel use as the primary causes of CC, highlights fundamental misunderstandings of these scientific phenomena. These misconceptions likely arise from the overlapping scientific concepts. Specifically, the distinction between global warming and ozone depletion is often blurred due to their shared association with environmental degradation. Media narratives and school curricula may not adequately differentiate these issues, leading to long-lasting misunderstandings. Besides, many pre-service teachers may not have access to up-to-date scientific literature, leading them to rely on outdated or oversimplified explanations. This is particularly concerning in contexts where CC education is not strongly emphasized in teacher training programs.

Addressing these misconceptions requires the integration of scientifically rigorous CC education in pre-service teacher education, ensuring that future educators have a clear and accurate understanding of CC causes, impacts, and mitigation strategies.

Attitudes and beliefs about CC science

Despite a high level of belief in CC existence (89.03%), pre-service teachers exhibit uncertainty regarding the scientific consensus on CC. Nearly half of them (43.55%) perceived CC conclusions as model-based and lacking sufficient scientific evidence while 83.55% believed CC science should rely on controlled experiments. This skepticism reflects broader societal debates about the reliability of CC science and underscores the need for better communication of climate research methodologies.

Moreover, while 82.1% of the pre-service teachers expressed concern about CC and willingness to take actions, some reported disinterest due to a lack of motivation or time constraints. This level of concern aligns with findings from other international studies (Seroussi et al., 2019; Wachholz et al., 2014). Additionally, this suggests that while CC is recognized as an important issue, it is not always prioritized in daily concerns or professional aspirations. Integrating CC discussions into teacher training programs in ways that connect scientific knowledge to real-world applications may help bridge this gap.

Teaching intentions and disciplinary differences

Encouragingly, the surveyed pre-service teachers demonstrated a strong interest in teaching CC topics, particularly mitigation and adaptation strategies. More than 75% expressed an intention to incorporate CC-related topics into their teaching, with personal actions to mitigate CC (55.2%) and CC mitigation/adaptation strategies

(52.6%) receiving the highest levels of commitment. However, the observed inconsistencies in their knowledge and confidence levels may hinder their ability to teach effectively once they become in-service teachers.

Disciplinary differences in teaching intentions, as reflected in the questionnaire results (e.g., significant differences in responses for variables B12.1, B12.3, B12.5, B12.7, B12.9, and B12.10), suggest that subject-specific expertise influences how comfortable pre-service teachers feel about integrating CC topics. These findings highlight the importance of interdisciplinary CC education in teacher training programs to ensure that all educators, regardless of their field, are prepared to address CC in their classrooms.

Study limitations and future research directions

While this study provides valuable insights into pre-service teachers' awareness and intentions regarding climate change (CC) education, several limitations should be considered. First, the sample size of 468 participants, though informative, is not fully representative of all Vietnamese pre-service teachers. Expanding future research to include larger and more diverse samples, particularly in-service teachers, would enhance the generalizability of findings. Additionally, the study is geographically limited, covering six public TEIs concentrated in northern and central Vietnam. The absence of data from southern institutions restricts broader applicability. Second, reliance on self-reported survey data introduces potential social desirability bias, where participants may provide responses they perceive as favorable rather than reflecting their true knowledge and attitudes. Third, the cross-sectional nature of this study limits insights into how pre-service teachers' knowledge and teaching intentions evolve over time. Longitudinal studies in the future could track changes in CC understanding throughout teacher training and early career experiences. Finally, future research should explore the role of institutional support, including professional development and school curricula, in shaping teachers' ability to integrate CC education effectively.

Recommendations for enhancing CC education in teacher training

To address the gaps and misconceptions identified in pre-service teachers' CC knowledge, teacher education programs should implement comprehensive strategies to enhance CC instruction.

First, CC should be integrated across disciplines, not just within science courses. Embedding CC topics into different disciplines ensures that pre-service teachers understand the societal, economic, and environmental dimensions of climate issues. Topics such as the impact of greenhouse gases, the effects of CO2, and contributing factors to CC should be taught more clearly to help pre-service teachers avoid misconceptions and gaps in understanding. This interdisciplinary approach fosters a holistic perspective, enabling teachers to address CC in diverse classroom settings.

Second, experiential learning opportunities should be emphasized. Hands-on projects such as climate data analysis, community engagement initiatives, and partnerships with environmental organizations can provide real-world applications of CC concepts. Field trips and interactive workshops will further reinforce scientific understanding and encourage proactive engagement with CC issues.

Third, teacher education programs should develop specialized CC education modules. These modules should cover fundamental CC science, clarify common misconceptions, and equip teachers with pedagogical strategies for effective instruction. Incorporating case studies and inquiry-based learning approaches will strengthen comprehension and teaching confidence.

Fourth, access to updated scientific research must be enhanced. Collaborations with climate scientists, open-access resources, guest lectures, and academic workshops can ensure that pre-service teachers receive accurate, up-to-date information. This approach helps dispel outdated beliefs and fosters trust in scientific evidence.

Finally, institutional support and policy integration are crucial. CC education should be mandated as a core component of teacher training, ensuring that all educators, regardless of discipline, are prepared to teach CC effectively. Additionally, professional development opportunities should be expanded for in-service teachers to continuously update their CC knowledge.

By implementing these strategies, teacher training programs can equip future educators with the knowledge, confidence, and skills needed to teach CC effectively, fostering a generation of scientifically informed and environmentally responsible students.

5. CONCLUSION

This study reveals that while surveyed pre-service teachers possess some understanding of CC, significant misconceptions persist, reflecting an unstable knowledge foundation. Despite their interest in CC, their beliefs remain inconsistent and, at times, contradictory. Moreover, attitudes, beliefs, and teaching intentions vary across fields of study. Given that CC is a "wicked problem" intertwined with global challenges such as food security, migration, and biodiversity loss (Cross & Congreve, 2021), addressing it requires interdisciplinary understanding and strong pedagogical competencies. Teachers must be equipped with not only accurate scientific knowledge but also the ability to integrate CC topics into diverse subject areas. To achieve this, we recommend incorporating CC education as a mandatory course or shared module for pre-service teachers across relevant disciplines, an approach that has proven effective in other countries (Wang et al., 2020). Additionally, experiential learning, access to updated scientific research, and institutional support are essential for enhancing pre-service teachers' understanding and confidence in teaching CC. By implementing these strategies, teacher education programs can better prepare future educators to foster climate literacy and empower students to engage with sustainability challenges effectively.

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